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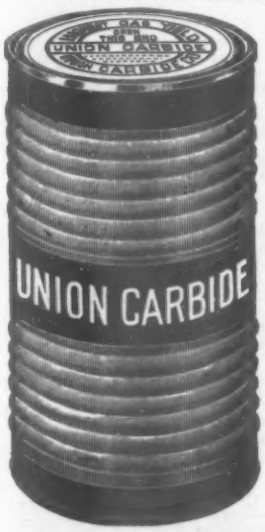

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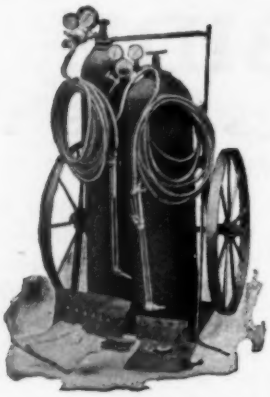

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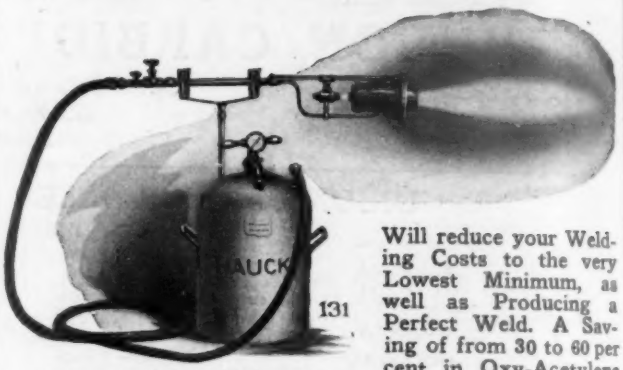

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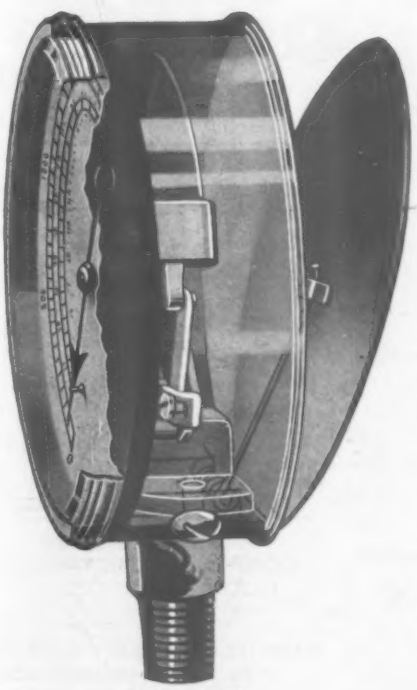

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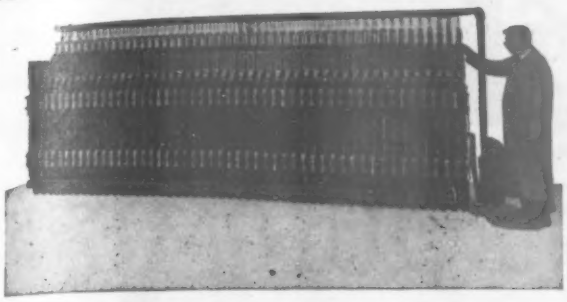

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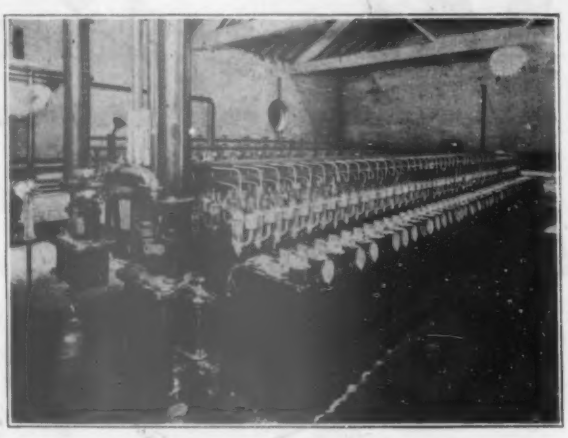

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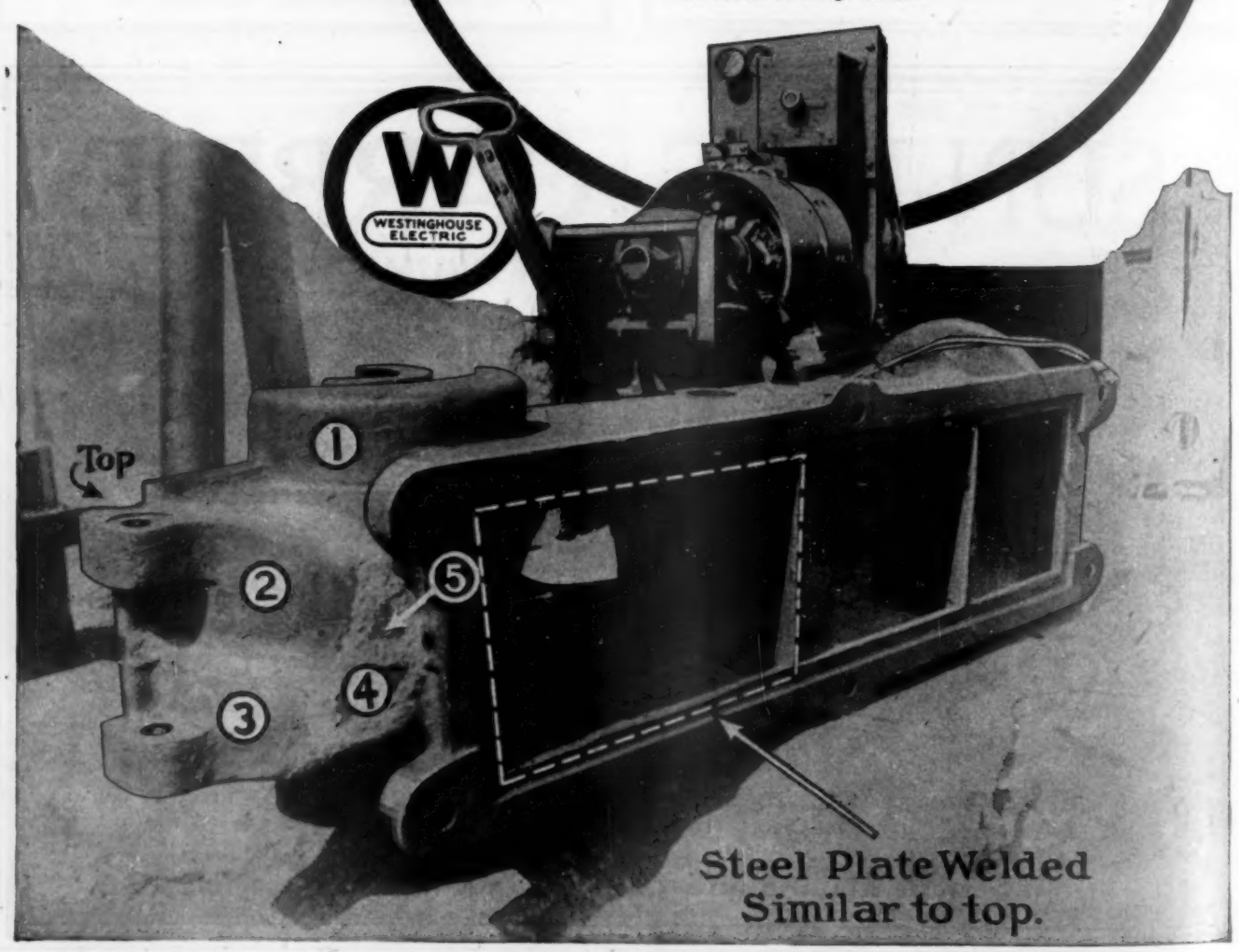

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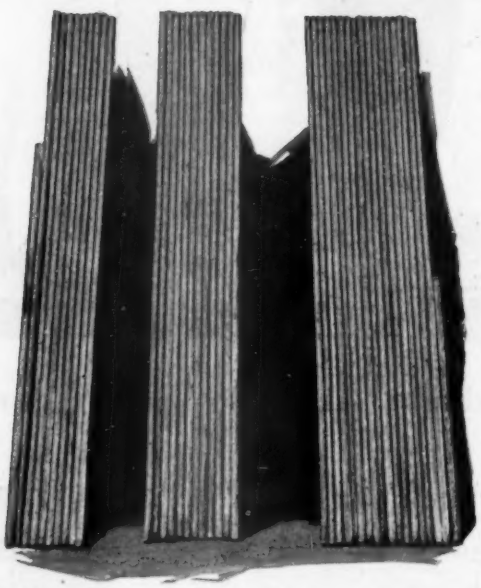

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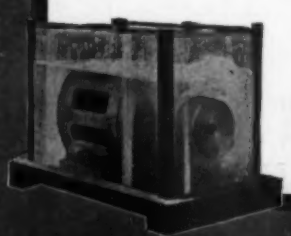

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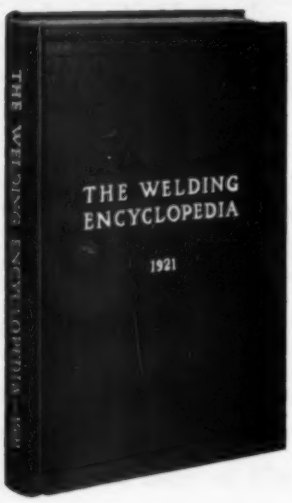

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How to Detect Malleable Iron—Brazing Malleable Iron—Rear Housing—Reinforcing the Braze—Brazing Tube to Housing—Building Up Worn Parts—Copper—Brass and Bronze—Silver Soldering.

CHAPTER VII.—CARBON BURNING AND OTHER USES OF OXYGEN AND ACETYLENE.
Principle of Carbon Burning—Method of Operation—Lead Burning—Soldering—Case Hardening—Heating Uses.

CHAPTER VIII.—HOW TO FIGURE COST OF WELDING.
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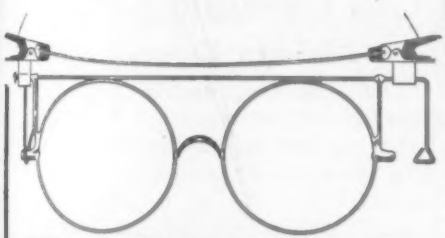

The Histed Novelty Goggle

FOR WELDERS

is attached to the welder's cap by means of two little spring clips that clamp to the visor of the cap and hangs clear of the face, thus avoiding the possibility of the face or nose being blistered by the hot metal touching the skin. The lenses are 2 inches in diameter, which gives ample eye protection and prevents the welder looking past the lens when welding overhead. Good ventilation is assured by the Goggle not being enclosed and admitting plenty of light, thus keeping the eyesight normal at all times—that is, not dilated as in enclosed Goggles. No moisture from perspiration can gather on lenses, thus keeping vision clear, adding materially to the welder's efficiency. When inspecting work, the Goggle may be swung to a raised position and back quickly, without loss of time at welding, or removing gloves, or laying down torch or welding rod—a great advantage over those using the elastic head-band or ear-bows. When Goggles are not in use they are swung to a raised position and held in place by spring, and may be worn on cap visor at all times without inconvenience. They are always ready and stay nicely in place, whether welding down or overhead.

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for notice of certain legal proceedings in which our Company and the Trade are deeply interested. We have been notified, however, that "No advertisements or reading notices will be published in the 'Welding Engineer,' or the 'Welding Encyclopedia,' which relate to legal proceedings of any kind." We are therefore unable to carry out such intention, but take this means of notifying the Trade that we will be glad, upon application, to furnish full particulars.

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Profit in Radiator Repair Work

A Department Which has a Logical Place in the Welding Shop. Systematic Handling Makes the Work Easy

WHEN the farmer drives his horse around to the village blacksmith shop to be shod he knows that it is the logical time and place to have any necessary repairs made on his wagon. The smithy is the man who can attend to all repairs that are needed. Likewise the truck owner who drives his truck to the repair shop expects to have his leaky radiator repaired in the same shop which can handle the welding on a broken frame. Radiator repairing is, in fact, a logical year-around source of revenue for every welding shop which caters to automobile and truck repair trade. Yet there are few shops that have succeeded in making the work consistently profitable, and a great many shops try to side-track radiator work altogether. They tell themselves that there isn't any money in it and they tell the customer that radiator repair work is not welding.

Try as he may, though, the welder cannot turn the work aside completely. Radiators will freeze and burst, will get damaged by accident, and will spring unexpected leaks—and they must be made serviceable.. The job welder has his choice of referring his customer to another shop or attempting the repair himself. It must be borne in mind that repairing a leaky radiator is not a welding job but a soldering job. The welding flame is too hot to use on any kind of radiator work, for the metal near the leak will become overheated and new leaks will develop. The procedure followed by the Rex Radiator and Welding Company of Chicago will be taken as a typical example of how a few shops handle this work.

Fig. 1. View of Radiator Department Showing Convenience of Equipment.

Four years ago this shop was started as a combination welding and radiator repair shop. Mr. W. H. Rex, president of the new company, had never had any experience at this sort of work, but he had an idea that the great demand for radiator repairs would mean good business for the shop that could

handle them along with ordinary job welding. His partner, Mr. J. R. Darby, was one of the oldest heads in the railroad welding game in the city, and shared the opinion of the possibilities of the new venture. Their enterprise has been rewarded by a steady growth of trade, last year's business totaling nearly fifty thousand dollars. This business is the result of making satisfied customers. The efficient handling of this volume of business is due to systematic methods applied to the different jobs that come to the shop. From the very start the welding department was kept carefully separated from the radiator department, and the purpose of this article is to explain the workings of the latter department. The first photograph shows the men at work on radiator repairs. As no two of these jobs are exactly alike, and as this shop has handled as many as forty radiators in a single day, it is scarely worth while to attempt to cover the subject of the actual closing of the leaks. Any man with good common sense, a little mechanical ability, and who is interested in his work, can learn to solder radiators more readily than he can learn to make sound welds. It is the shop arrangement and the method of handling that count in production.

Fig. 2. Welding Department. Both Gas and Electric Processes are Used.

The photograph (Fig. 1) shows three large tanks along the side of the shop. These tanks are made of two-inch planks and lined with galvanized sheet metal. Around three sides of each tank is a shelf, of two-inch plank, with an opening cut large enough to permit the workman to stand close to the body. This arrangement makes it possible for him to stand where he can use the shelf for a work-bench and also handle the radiators in the water without difficulty.

In the space between two tanks is a table for holding the tools required by two workmen. Each man has two soldering irons, a small furnace for heating them, a small gas torch, an air hose for testing radiators, soldering flux, a small frame made of angle iron, pincers, and accessory tools. Fig. 4 is a diagram of the important parts of the equipment. Along the wall are three pipe lines carrying water, air and city gas. The water is used to keep the tanks full. The air is used for testing radiators and for the soldering torches. The gas is used in the soldering torches and for heating the soldering irons. When a radiator is brought into the shop it is first tested to locate the leak or leaks. To do this it is placed on the shelf of the tank and plugged carefully. A set of standard plugs can be purchased that will fit a good many radiators, but if an odd size is found the openings are plugged by soldering discs of tin over them. The overflow outlet can be plugged with a drop of solder. One of the plugs used is fitted with a spout air hose connection. The hose is attached to the radiator, as shown in Fig. 3, the air turned on and the radiator placed in the tank. Small bubbles immediately locate the leaks. The leaks that are most accessible are soldered with the iron. Those which are located in corners or inside the honeycombing are easily reached with wire solder and the gas torch. This gas torch is easily constructed from two pieces of small brass tubing, and using city gas with compressed air gives a flame that is hot enough to melt the solder without damaging the adjacent joints. The oxy-acetylene flame is both too hot and too expensive for this work.

From the time that the work is started until it is made air tight the radiator is kept close to the tank, where the test can be made in a few seconds. Compressed air is supplied from an air-compressor located at the end of the shop. The compressor is fitted with an automatic check valve which keeps the pressure up to ten pounds all the time. When the pressure gets low the motor starts automatically and runs until the required pressure is again established.

A careful study of the photographs will show that the main feature of this shop is the convenient system for doing the work. Each workman has a complete set of tools that he needs and a place to work so arranged that he can complete the repair without walking all over the shop to look for tools or materials, and without unnecessary handling of the radiator. That is, the arrangement and the system are time savers. This is very important because the work must not be allowed to drag. Most customers know that the work is a simple case of soldering and would resent the charge that would have to be made if the job were not handled quickly. This shop keeps a full barrel of soldering flux in reserve at all times, orders acid swabs by the gross and solder a few hundred pounds at a time, so materials will not run out when jobs are waiting. The ready-made plugs mentioned above and illustrated in Fig. 5, save their cost in a week through the difference in time between inserting them and soldering on a

tin disc. Figure 5 also shows how a spout can be made for a radiator which cannot be fitted with one of the standard sizes. A tin disc is soldered over the intake, a hole punched in the disc with a center punch, and a brass spout soldered over the hole.

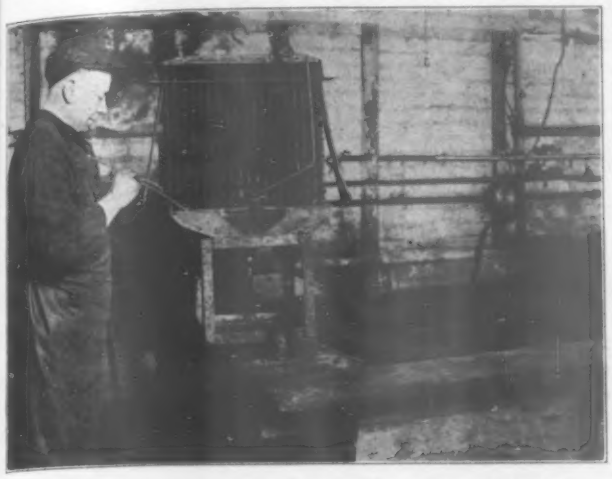


Fig. 3. Using Angle Iron Frame to Support Radiator.

It will be noticed that the equipment used by one workman is simple and inexpensive, yet he is prepared to handle any kind of radiator repair from a single leak to the installation of an entire new core. The procedure is: Find the leak;

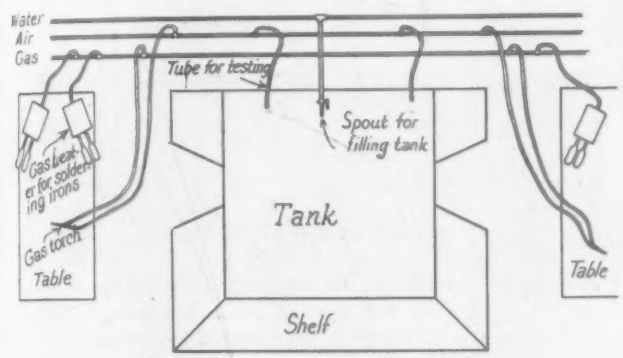


Fig. 4. Detail of Tank Equipment.

solder it; test for additional leaks and solder them; straighten the fins with pincers if they have become bent. Figure 3 shows the use of the small angle-iron stools for holding the radiators in position where soldering can be done comfortably.

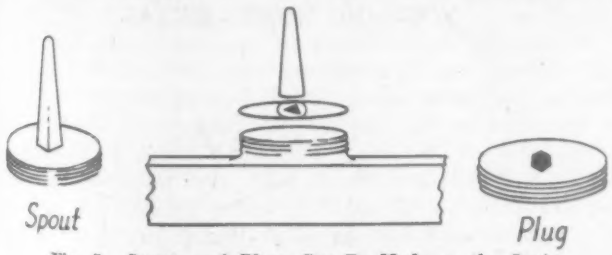


Fig. 5. Spouts and Plugs Can Be Made on the Spot.

The repairman soon learns to take care of the job with minimum effort and expenditure of time. These time-saving details were not learned in a day, they are the result of carefully studying out ways and means to eliminate waste motion. The simplicity of the method of doing this work makes it readily adapted to the shop which has a smaller volume of such business to solicit. The construction of a single tank is a small matter, the air can be supplied with a foot blower in case the installation of an air compressor is not desired (though the latter is very desirable for the operation of pneumatic tools and sand blasts) and all the necessary tools mean an insignificant investment.

A view of the welding department in this shop is shown in Fig. 2. It operates independently of the radiator department, and is equipped for doing both oxy-acetylene and electric arc welding. In addition to the motor generator arc welding set and the welding torch is a well constructed preheating furnace, and a portable electric grinder. Over the preheater, which burns city gas, is a hood of galvanized sheet iron, fitted with weights and pulleys so that it can be raised or lowered easily. Its usefulness in preheating automobile cylinder blocks would be hard to estimate, since it gives an even heat on the cylinder block and at the same time leaves the operator a comfortable place in which to work. When the parts to be welded are covered with oil or grease a damper in the hood is left open long enough to allow the oil to be completely burned away, then closed to retain the heat in the furnace. Gas blowers placed at each end of the furnace provide for additional local heating. The welding shop handles the usual variety of repair work.

A WELDER'S WINDOW DISPLAY

The Kansas City Oxygen Gas Company keeps its line before the public by displaying a complete line of welding and cutting equipment and other gas equipment in the store

Gas Equipment Well Displayed.

window. The use of the store window in this way gives the store a real boost, and is a useful step forward in educating the public on the proposition that welding is one of our most important crafts and that it is here to stay.

THERMIT WELDING GALVANIZED PIPE

Galvanized pipe is feasible to weld by means of the Thermit butt welding process, according to a statement by the Metal & Thermit Corporation, New York. In preparing galvanized pipe for the weld, as much of the galvanize as possible should be removed by filing or burning off. This, of course, applies only to that section of the pipe which comes within the mold. All other procedure is the same as for black pipe. The same molds and portions of thermit as used for black pipe can be used for galvanized pipe, but as there is a very slight eruption or explosion, caused by rapid volatilization of the zinc in the galvanize shortly after pouring the thermit, it may be that on larger sized pipes or in the case of a heavy galvanized coating that has not been previously sufficiently removed, a 10 per cent increase in the portion may be beneficial.

The objection that the galvanized surface within the welded zone will be destroyed is offset by the fact that the pipe walls within the zone are made slightly heavier, due to the upsetting and, therefore, would have longer life on that account. As a matter of fact the threaded ends of galvanized pipe are not galvanized and as this thread greatly reduces the wall thickness, the loss of galvanize on the welded pipe is evidently of small significance.

Hints for the Welder

When you finish an interesting piece of work, can you set down on paper the manner in which you went about the job, how you prepared the work and how the job was done? Have you learned some little stunt every welder ought to know? Contributions to this department are paid for. Write it down any old way – I'll polish it up. Make a rough pencil sketch and our draughtsman will fix it up fine. Line drawings are more practical than photographs. Do it today – the men on the firing line are waiting. L. B. Mackenzie, Editor.

WELDING STREET CAR SIDE FRAMES

One of the most troublesome jobs that come to the street car repair shop is the Brill Type 27G truck side frame. There is a weak point where the journal box shim bolt goes through, as shown in Fig. 1, and any amount of reinforcement makes

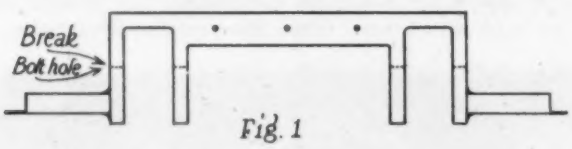


Fig. 1

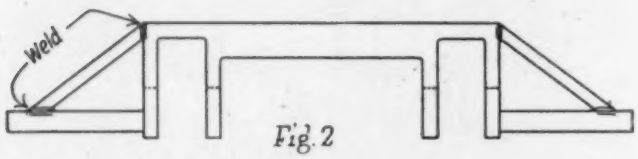


Fig. 2

it unsightly. To overcome this difficulty and prevent future breaks these frames are welded with the electric arc and reinforcement braces are added. The brace does not mar the appearance of the truck side, but gives it the appearance of a bridge truss, as shown in Fig. 2.

ELECTRIC ARC AS AN AID TO PHOTOGRAPHY

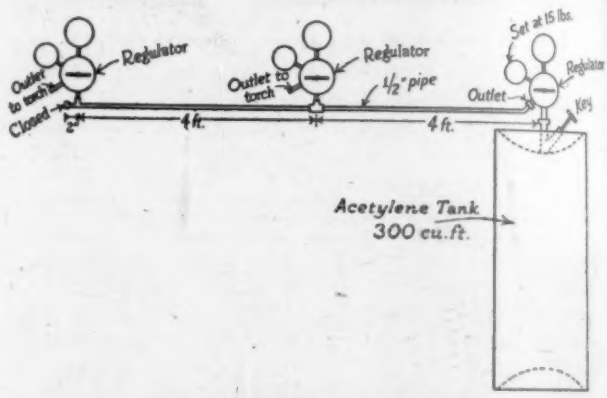
Very often the photographs taken in the interior of a shop are indistinct on account of the poor lighting. This is also true of pictures taken in the interior of fire boxes. The

Photos Taken By Electric Arc.

welder who is using the electric arc process can get better pictures by using the arc to supply the light. Two pictures taken with the aid of the arc are reproduced herewith to show how well it brings out the details of the job.

ONE TANK—ONE WELDER

Question: Herewith is a sketch showing two welders working from one tank. I would like to try this out. At present I do not want to buy another tank. The welding I wish to do is all light work and the torches are equal pressure. The gauges are all the same, and I am considering having the regulators on the tank set at fifteen pounds. The



Not a Good Way to Cut Expenses.

torches will not always be working with the same size tips. I only want to use this system for a few months because I realize that a tank for each man would be the best.

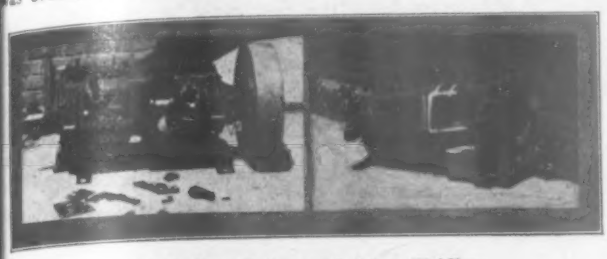
Reply: This is bad practice because it is certain to draw the acetylene from the tank a great deal faster than it should be taken away, which results in drawing some of the acetone away along with the acetylene. Acetone is bad for welds and expensive to replace.

WELDING MONEL METAL

Monel metal is not difficult for the operator who knows how to weld cast iron or aluminum and how to take care of expansion and contraction. Use a soft flame with an excess of acetylene, so that the second cone extends about 5/8 inch beyond the small flame. The pieces must be beveled and welded as fast as possible so that the metal does not get too hot and form blow holes. Use monel welding flux or borax. Also use rather heavy monel welding rods. When welding sheets of monel, bevel the edges and then add enough metal to more than fill up the groove so that the seam becomes heavier than the sheet itself. Try to melt the metal only once, that is, do not go back over your work to try to fill up the cracks. If a crack occurs in the weld do not go over it while hot. Finish up the seam you are welding, then let it cool; take a hammer and bump the place where the crack is, over a width about three or four times the thickness of the metal, then weld over. When cool beat the sheet back as it was, but never attempt to hammer the sheet while hot. When welding sheets together make a little greater allowance at the ends for welding steel sheets. If you weld fast, however, the allowance for contraction will not need to be so great.

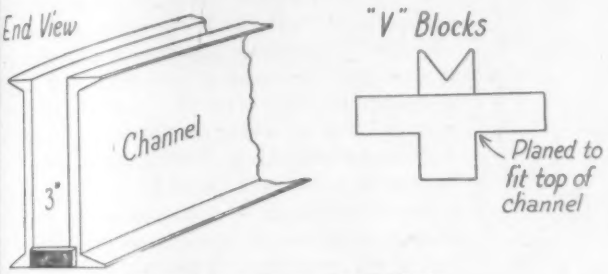
FRAME FOR V BLOCKS

The accompanying photographs show a Reo crank case that was broken in several pieces, reclaimed by welding, and is



Crank Case Before and After Welding.

now giving good service. Small jobs of this nature are greatly facilitated by the use of "V" blocks, which can be handled



Channel Iron Frame for V-Blocks.

to good advantage by making a frame for them as illustrated in the sketch. Two pieces of channel iron 40 inches long are

The V-Blocks Are Kept Ready for Use.

set apart 3 inches and tied together with straps welded at each end and the bottom. The photograph of the shop shows this device on the bench ready for use.

METHODS OF OBTAINING EXPANSION ON BROKEN LOCOMOTIVE FRAMES

When the break is at (A) as shown in sketch:

First. Drop binder from pedestal (K); then set a screw jack under binder fit (K); tighten up a sufficient amount to get frame in proper alignment.

Second. Cut a piece of bar stock of any kind that has cross sectional area enough so there is no danger of upsetting or bending, place it as shown in sketch at (E) between (L) and (M) with space enough at (J) to admit a wedge (the wedge used for this should have not more than $\frac{1}{8}$ taper to the inch and made of carbon steel of about common spring grade.

Drive wedge at (J) and watch the break to see if it opens, if not start a wedge at break (A); drive both wedges at the same time. When sufficient expansion is obtained remove wedge from break, then bar (E) will hold expansion. Some welders advocate cutting jaw at (I) to get expansion, but I have found by heating this point to a dull red heat it can be sprung enough to get the proper amount of expansion. Then after the weld is finished heat this section to a good red heat, so it will straighten up when the weld cools. This saves one weld also considerable gas, time and welding material, as I think everybody concerned will agree that the least number of welds you have, the better.

Third. When the above method fails place a bar from (C) to (D); drive wedge at (G), usually with bar (E) and bar

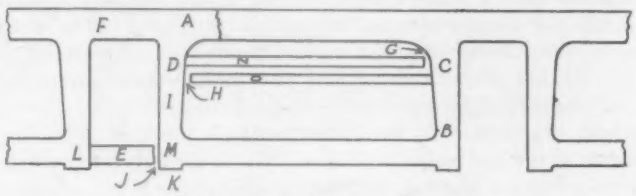


Diagram of Locomotive Frame.

(N). We can get the proper amount with heating at (I), but if this fails, place the next bar (O) just below bar (N) with about 1½-inch space between the bars, then drive wedge at (H) with two heavy hammers, drive (G) and (H) at the same time. When this will not obtain the proper amount, place a piece of asbestos paper between bar (N) and (O), then take a large welding head and play the flame on bar (O) at the same time driving wedge (G) as the expansion opens up the break, using care not to get the bar hot enough to upset. When you think you have obtained all the expansion possible from bar (O) then take a water hose and cool bar (O) off, reset wedge (H), drive up hard and repeat the heating operation as many times as is necessary to get the desired amount of expansion.

By giving a little study to this it can be readily understood and applied to many other welds located in different places by the use of last operation named. We are taking advantage of the greatest obstacle that we have to contend with in the amount of expansion.

TWO-TON FILTER PRESS HEAD REPAIR

A typical example of the use of oxy-acetylene welding in oil refineries is afforded in the repair of a 4,100-pound cast iron filter press head, which was badly broken in service at a wax plant operated by the Pierce Oil Corporation, at Sand Springs, Okla.

The weld was approximately 4 ft. 9 in. long with an av-

Filter Press Head Gas Welded.

erage thickness of three inches, and 175 pounds of cast iron filler rod was used on the job. The work was done by the Dubler Welding Company, of Tulsa, Okla., and including the time occupied in preparing, preheating, welding and cooling,

STANDARDS FOR TESTING WELDS

To the Welding Industry

WE are submitting herewith specifications for Standard Tests of Welds. Standardization of the procedure in making a test of any kind is obviously necessary before results obtained by different observers can be compared.

The chief difference between testing a specimen of steel that includes a welded joint and testing an ordinary specimen is the non-homogeniety of the welded specimen. The welded specimen has its center, a section composed of material that usually has physical, chemical and metallurgical characteristics distinctly different from the adjoining metal. Furthermore, the section of the added metal is more or less irregular in shape and variable in size. Consequently the procedure prescribed for testing of ordinary specimens is not applicable to specimens containing welded joints.

Differences in details of procedure have caused widely divergent results that comparisons are frequently impossible, with the results that the usefulness of much of the research work on record is generally restricted and in many cases the results are actually misleading.

Although more thorough research work in this field may develop more satisfactory standards for tests of welds, the need for some immediate standards is so great that the universal use of the accompanying specifications is urged upon all those who have to do with the testing work in this field. Criticisms and suggestions are invited. The present standards will be valid for a period of one year and at the end of this period they will be modified if it is found desirable.

C. A. Adams,
Director, American Bureau of Welding.

Report to the Bureau of Welding of the Committee on Standard Tests for Welds

THE committee held a meeting on February 3, 1921, at the Engineering Building, New York. After some discussion of its two fields of activity, namely preparation of standards for comparing welds and standardization of tests to be applied to welds in finished structures, it was concluded that (a) the committee should first work on standards for comparing welds and (b) the material prepared by a similar committee under the Welding Research Committee of the Emergency Fleet Corporation, which was the result of a great deal of work on the part of several men, should be utilized as fully as possible.

The committee in preparing the "Standards for Testing Welds," which are transmitted herewith, proceeded on three assumptions as follows:

1. The fundamental basis of measuring the effectiveness of of a joint between two pieces of metal is the best metal without a joint. A joint is a necessary evil in a structure which is avoided when it is possible. Therefore the value of a joint is best determined by comparing the characteristics of a section of the structure which includes the joint with those of a similar section which has no joint. In other words, a weld is a joint and the practical basis of evaluating a weld is in terms of the metal of the parts joined together.

2. Three standards are desirable as follows:

   (a) *Shop Standard.* In the shop a standard test is required for such purposes as checking the work of a welder from time to time, testing a new lot of electrodes in electric welding or of welding wire in gas welding, testing the effect of some change in conditions which may have taken place, et cetera. Such a standard must necessarily be as simple as possible and preferably a single test. The technique of the procedure in making the test must be of a simple character.

   (b) *Commercial Standard.* There are many cases where more than one kind of test should be made, but where the circumstances do not justify a complete investigation. There is, therefore, a need for what might be termed a commercial standard for making, for example, comparisons between different commercial welding processes or between different kinds of electrodes in electric metal-arc welding or different wires in gas welding.

   (c) *Research Standard.* When a complete investigation of a weld is to be made for research or other purposes, all tests and examinations are made which will contribute any information in regard to the characteristics of the weld. It may be necessary to make tests of a special character in special kinds of welds or where application under unusual conditions is contemplated, but there should be a standard list of tests which will give information which is complete as far as all ordinary requirements are concerned.

3. The details of the procedure in making the various mechanical tests should be carefully prescribed. It is believed by the committee that standardization in this respect is of the greatest importance because comparatively small differences in procedure have a marked influence in certain mechanical tests and unless these are eliminated the results are not comparable.

The committee recommends that the proposed "Standards for Testing Welds" be adopted, at least tentatively, and be offered by the bureau for general use. It may very well be that experience will show the desirability of making changes but that can only be determined after the standards are in use.

Respectfully submitted,

W. J. Beck,
S. W. Miller,
R. E. Wagner,
H. L. Whittemore,
F. M. Farmer,
Chairman.

STANDARDS FOR TESTING WELDS

Note: These specifications are intended primarily to serve as a standard, uniform basis for testing and comparing sample welds as distinguished from welds in structures. The testing of the latter must necessarily be by non-destructive methods which would therefore be, in general, quite different from those employed in examining sample welds (test welds) made, for example, for the purpose of testing a welder's proficiency, comparing welding wires or comparing welding methods.

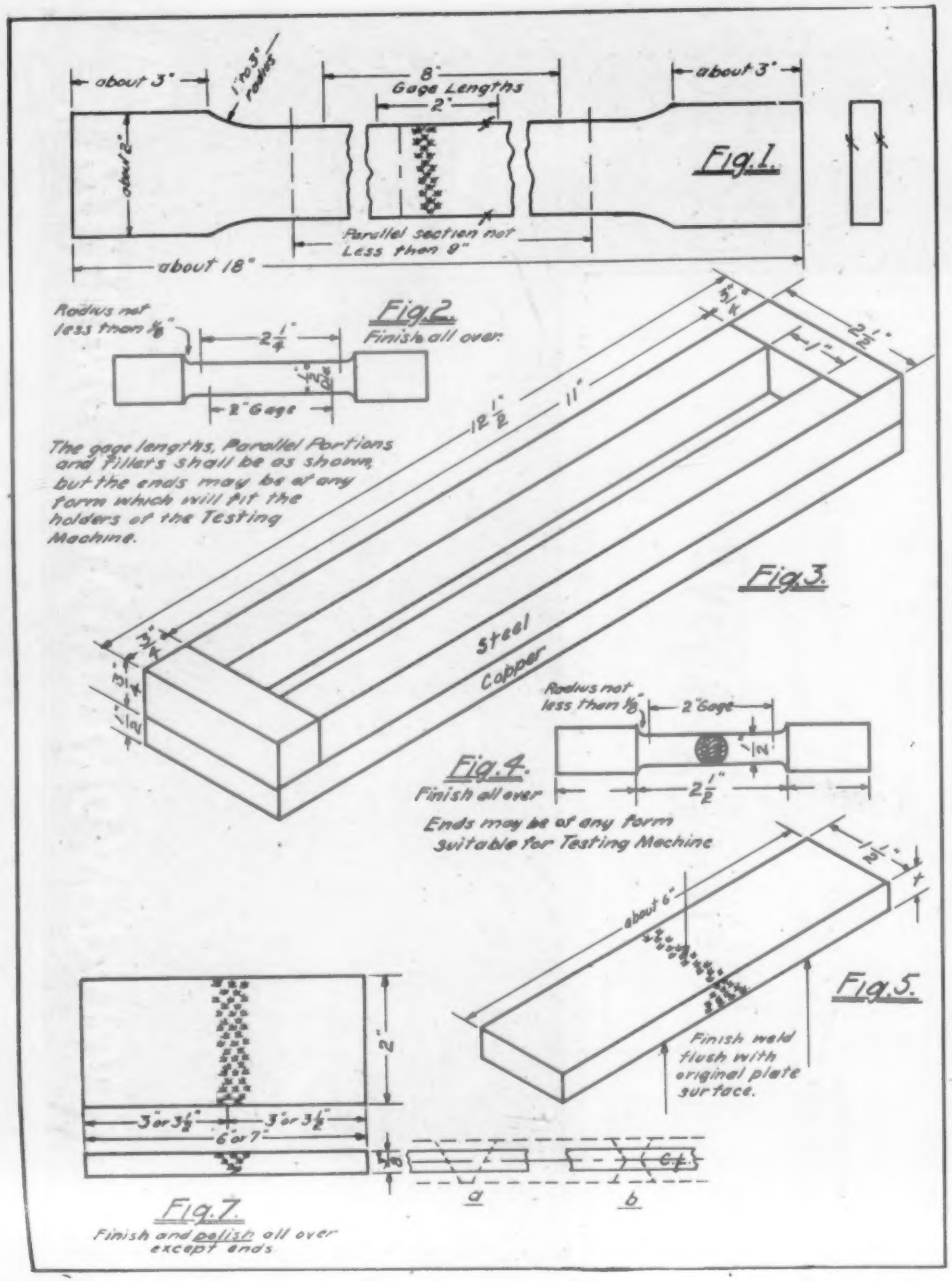
I. Definitions

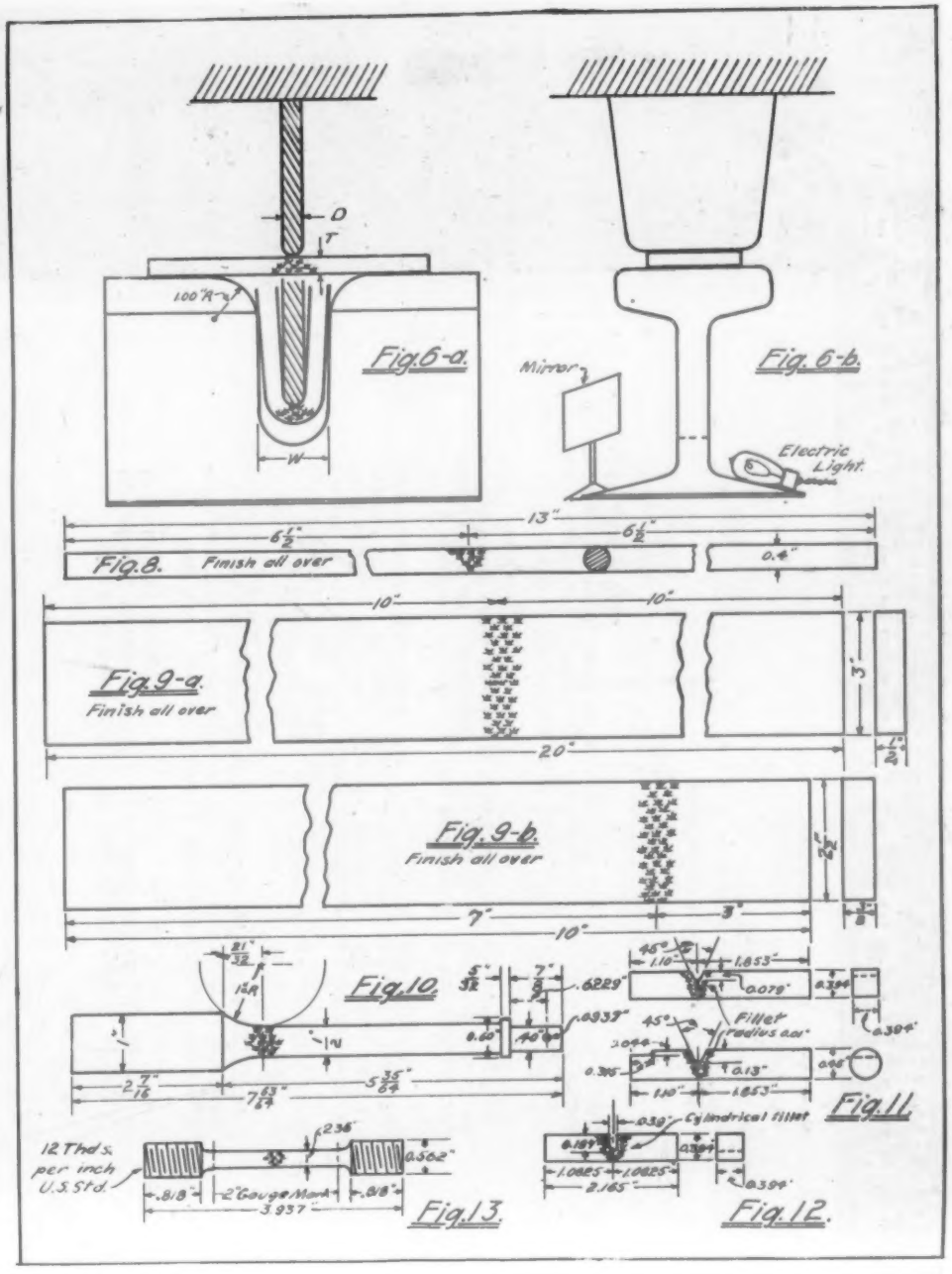
THE following are definitions of terms employed in this specification.

(a) A *Weld* is a solid union of metallic pieces formed by uniting or consolidating by hammering or compressing with or without previous softening by heat.

Note: This definition is quoted from the Century dictionary. It is the broad definition of a weld and therefore includes forge welding and resistance welding by either the butt or spot process. While these specifications are prepared specifically for fusion welds, it is obvious that some of the tests can be applied to other types of welds.

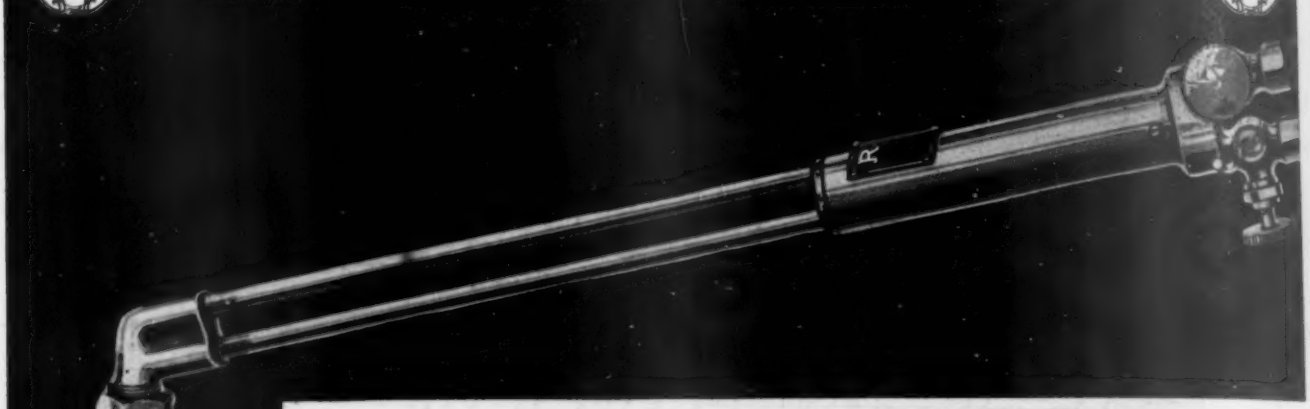
(b) A *fusion weld* is a weld formed by heating to a fluid state the edges of the pieces to be joined and allowing the metals to flow together (with or without additional molten metal being supplied) without any pressure being applied. The heat may be





Standard Specimens for Welding Tests.

REGO WELDING AND CUTTING APPARATUS



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COLUMBUS, OHIO
"RED HEAD" PRODUCTS

S. D. WINGER, Vice Pres. & Gen. Mgr.

REC'D 2/25
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WELDING & CUTTING EQUIPMENT, WELDING SUPPLIES

Bastian Blessing Co.,
Chicago, Ill.

February 22, 1921.

Gentlemen:

Since we have taken on the distribution of REGO equipment, we have made a discovery which may be of interest to you.

You have probably noted that many makes of equipment use two piece tips. The trouble with these tips is that the interior brass cores deteriorate rapidly, ruining the whole tip.

The Blank Railway, one of our large accounts, spent $761.00 for tips alone last year. We have just received orders to re-place the equipment on this system with REGO. This was due to the REGO one piece solid copper tip. We have convinced them that they should practically eliminate the item of tip maintenance.

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A large steel casting company spent $400.00 last year in tips. We have just re-placed all their present equipment with REGO on account of the REGO solid copper one piece tip.

Yours truly,

The Gas Products Co.

S D Winger

THE BASTIAN BLESSING COMPANY
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WELDING AND CUTTING APPARATUS

Buy REGO for Tip Economy

Tip maintenance cost alone, with equipment less well designed than REGO, can equal the original purchase price of the entire outfit, in one year's service.

REGO outfits are equipped with one piece, drawn copper tips. The pure copper used in REGO tip construction resists the tremendous heat of the welding flame better than any other metal known.

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REGO one piece tips not only afford the economy of saving practically all the usual tip re-placement costs, but offer a type of seat construction which eliminates gas leakage at the tip. There is no chance of the gases mixing prematurely.

Write for our new booklet on principles of gas mixture.

"FACTS"

An authoritative presentation of the real principles of welding as they are related to economy and service.

Your inquiry will receive immediate attention

Buy REGO for Tip Economy

THE BASTIAN BLESSING COMPANY
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supplied by a gas flame, an electric arc thermit or otherwise.

(c) In a fusion weld, the ***base metal*** is the material composing the pieces to be united by the weld. Unless otherwise expressly stated, it will be understood that a weld joins two pieces of identical material.

(d) In a fusion weld, the ***weld metal*** is the material which has been used in forming the weld. It may consist entirely of a base metal adjacent to the weld or of the material added to the fused base metal from a welding rod or electrode, or other material.

(e) *Filling metal* is the metal added during the welding process to form part of the weld. In gas welding it is supplied by means of a *welding rod,* in carbon arc by *filling rod* and in metal arc welding by the *electrode.*

(f) A *test weld refers* to a sample of welding which has been performed under known conditions and upon which mechanical tests are to be made.

(g) A *test specimen* is a prepared piece on which a mechanical test is to be made.

II. Shop Standard

Bending test only.

III. Commercial Standard

(a) Bending test

(b) Tensile test

Note: It is probable that eventually it will be desirable to include a fatigue test when a method is standardize which will be suitable for commercial application.

IV. Research Standard

A. Tests of base or parent metal.

1. Chemical analysis. To include carbon, manganese, silicon, phosphorus and sulphur.
2. Mechanical Tests
   (a) Tensile. To include yield point, ultimate strength, total elongation and reduction of area.
   (b) Bending
   (c) Fatigue
3. Metallographic. Photomicrographs at 100 diameters.

B. Test of weld

1. Mechanical tests
   (a) Tensile. To include yield point, ultimate strength, total elongation and reduction of area.
   (b) Bending
   (c) Fatigue
   (d) Impact
2. Metallographic. Photomicrographs at 100 and 500 diameters respectively at (a) the junction between the base metal, and the filled-in metal, (b) the base metal adjacent to the junction, (c) the center of of the filled-in metal.

C. Tests of filled-in metal.

1. Chemical analysis. To include carbon, manganese, silicon, phosphorus and sulphur.
2. Mechanical tests. Standard round specimens to be prepared from ingots deposited in a base-metal mould of such dimensions that normal cooling conditions will be approximated.
   (a) Tensile. To include yield point, ultimate strength, total elongation and reduction of area.
   (b) Bending
   (c) Fatigue
3. Metallographic. Photomicrographs at 100 and 500 diameters respectively.

V. Standard Procedures for Mechanical Tests

1. *Preparation of Test Welds*

No detailed instructions for the preparation of test welds can be given as the dimensions, material, etc. will depend upon the purpose for which the weld is being made. The test weld should, however, duplicate as nearly as practicable, the commercial welds which it represents and should preferably be of such a size as to permit preparations of enough specimens from the one test weld to make all of the mechanical tests which are to be made.

When the test weld is made with material in sheet or plate form, the longest axis of the test specimen should in general, be parallel to the direction of rolling.

2. *General Procedure*

(a) Wherever applicable, the standard procedure of the American Society for Testing Materials as given in the A. S. T. M. for 1918 (serial designation E-1-18) shall be followed.

(b) Three duplicate specimens shall be tested in any one test and the average taken as the value of the property determined by this test.

3. *Tensile Tests,—Base Metal*

(A) Test Specimens

(a) *Sheet or Plate Material.* The test specimen for sheet materials is shown in Fig. 1. The thickness of the specimen may be any that is desired, but a thickness exceeding ¾ inch would require a testing machine in excess of 100,000 lb. capacity. If the specimen is cut from standard sheet material, it is usually not necessary to machine the 1.5 inch faces of the specimen.

(b) *Cast Material.* The test specimen for cast or brittle materials is indicated in Fig. 2*. It is particularly important to use swivel specimen holders when testing such specimens in order to entirely eliminate undesirable stresses.

(B) Test Results to be Recorded

(a) *Ultimate Strength.* Unit stress (lb. per sq. in.) computed from the area of the original section.

(b) *Yield Point.* Unit stress (lb. per sq. in.) at which marked increase in deformation of the specimen occurs without increase of load as indicate by a sudden dropping of the beam of the testing machine or by a sudden increase of the rate of elongation as shown by dividers.

(c) *Contraction of Area.* Expressed in per cent of the original area.

(d) *Appearance of Fracture.* The appearance of the fracture as determined with the aid of a low power magnifying glass (such as jewellers use) should be recorded. The characteristics described by the following nomenclature should be covered indicating as far as possible the per cent of the total area which is involved. For example, "10 per cent not welded" would signify that approximately 10 per cent of the total area of cross section at the fracture is exposed base metal—that is, not welded.

Spongy: Full of small cavities; the structure resembles that of a sponge; porous.

Slag inclusions: Foreign matter entrapped in the weld.

Gas pockets: Small or large cavities more or less isolated (i. e., not of a regular spongy structure.)

Not welded: Exposure of any portion of the surface of the base metal indicating imperfect fusion between the base metal and the filling metal.

Laps: Imperfect fusion between adjacent portions or between successive layers of filling metal.

(The recording of the following data is optional.)

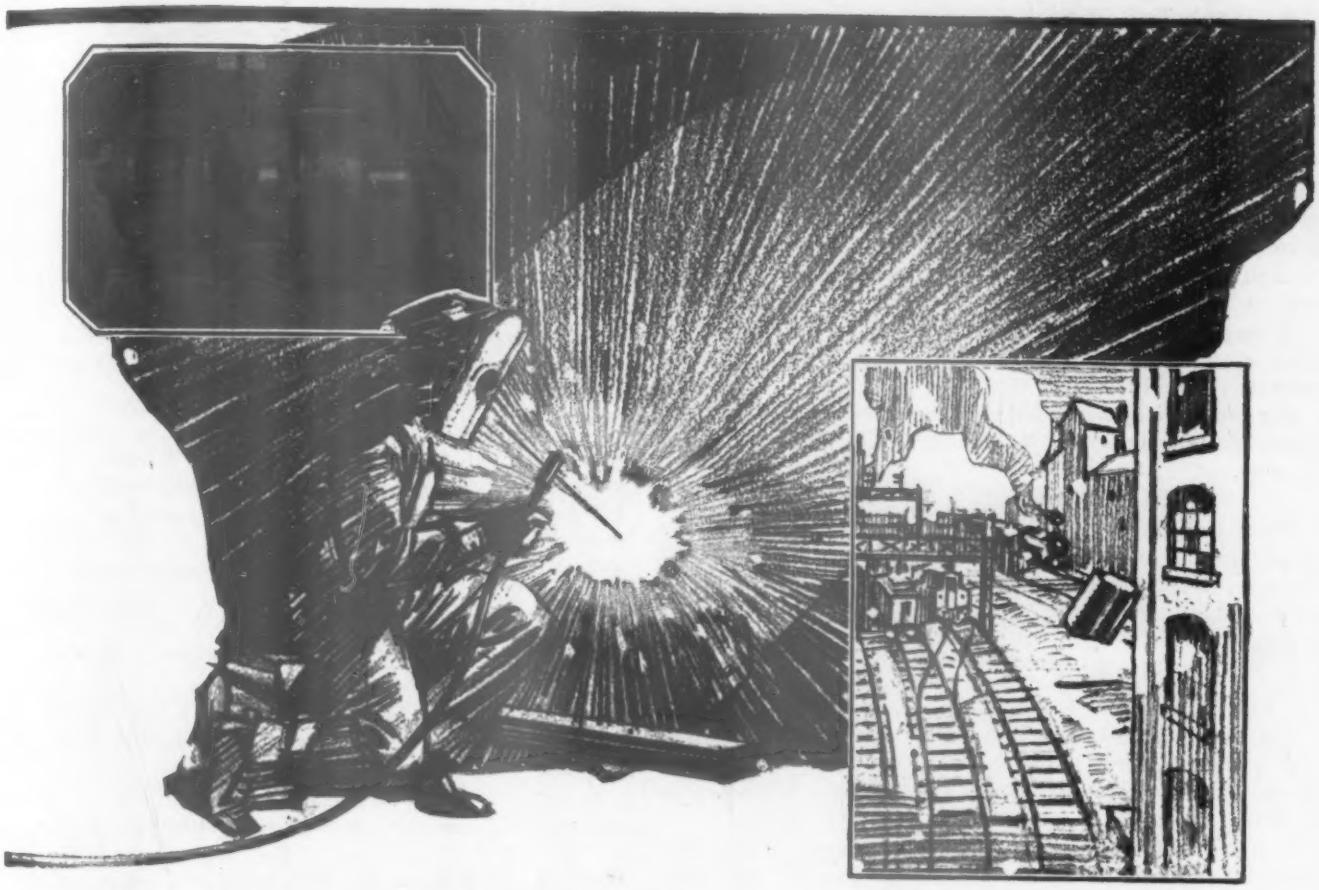
(e) *Proportionately Limit.* Unit stress (lb. per sq. in.) at which the deformation ceases to be directly proportional to the load.

*Any type of extensometer may be used but in precise work the deformations of two opposite elements of the specimen, preferably on the edges, should be obtained. For ordinary purposes deformations in only one element of the specimen need be measured, but inthat case the gauge marks should be on the center of the line of the 1.5-inch side.

The gauge length may be either 2 or 8 inches.

*The diameter of this specimen may be 0.505 inch if desired. This diameter gives an area of exactly 0.200 square inch.

Sometimes the producer is so absorbed with the task of producing, that he overlooks means which might make his plant more productive



A Welded Seam with All the Strength of the Original Metal

Full of oil and sealed tight a tank was dropped from a four-story building onto a railroad track, and nothing but a dent in the tank! A real test of strength, and yet the electric arc welded seam did not leak or show a sign of weakness. Electric welding makes every seam a part of the product itself, rather than a connection which merely holds it together.

In every industry wherever metals are joined together, the electric weld is stronger, more durable, and permits special construction and more efficient design of parts than is possible with bolts and rivets. Its uses are so varied that in places where it is installed for a certain purpose, it soon develops a greater usefulness as men become more familiar with its operation.

To make electric arc welding a real factor in production, the General Electric Company has developed arc welding equipment for almost every purpose, large and small, suitable for factories where there is enough welding to keep one or many men busy.

Whether your welding problems require a small portable set or a large stationary outfit, the knowledge and experience of G-E specialists and their co-operation are available for the asking.

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(f) *Modulus of Elasticity.* Unit stress (lb. per sq. in.) computed from data obtained from a specimen having an 8-inch gauge length; measurements to be taken on two opposite elements, one on each edge of the specimen.

(g) *Total Elongation.* Gauge marks shall be laid off every inch along a line at the center of one of the 1.5-inch faces of the specimen before placing in the testing machine and the total elongation in every inch after rupture recorded. The total elongation in the 1-inch, 2-inch and 8-inch (if any) length which included the break shall be reported.

4. *Tensile Tests, Weld Metal*

A. Test Specimens

The shape and dimensions of the test specimens are shown in Fig. 2. It shall be prepared from a bar of *weld metal,* ¾ by 1 by 11 inches. This bar shall be formed entirely by depositing filling metal in an open box of the shape shown in Fig. 3, employing exactly the same method used in making the corresponding *test weld.* For metal electrodes this box shall consist of a copper plate ½ inch thick, upon which is secured a frame of steel bars, ¾ inch square. The parts of the box were secured in any convenient manner. The copper plate, during this operation shall rest upon a steel plate. After the bar is formed, the copper plate and the frame may be removed by any suitable machining operation.

For gas welding, the copper plate should be replaced by a steel plate. For thermit, a box of suitable refractory material should be used.

(B) Test Results to be Recorded

These shall be the same as those prescribed in Section V, 3-B (base metal) except those involving an 8-inch gauge length. If, however, the modulus of elasticity is desired, a specimen similar to that shown in Fig. 2, with a gauge length of 8 in. shall be employed.

5. *Tensile Tests, Weld*

(A) Test Specimens

The shape and dimensions of the test specimen are shown in Fig. 1 with the weld at the center. If the material is cast or brittle, the specimen shown in Fig. 2 shall be used with the weld located at the center.

It is especially necessary that the 1.5 inch sides of the specimens be machined, particularly if the two pieces of base metal are offset or if they form an angle at the weld. Tests made in the latter case, where the specimens are not machined, are not reliable. Furthermore, care must be taken that specimens having the latter defects are not "straightened" before being machined because such treatment is likely to materially decrease the strength of the weld. A roughning cut in a planer or shaper which will just "close up" the surfaces of the specimen is sufficient.

(B) Test Results to be Recorded

The requirements for test results given in Section V, 3-B (base metal) shall be followed.

6. *Bending Tests, Base Metal, Weld Metal and Weld*

(A) Test Specimens

(a) *Base Metal and Weld.* The shape and dimensions of the specimen are shown in Fig. 5.

In the case of welds in flat rolled material, the surface of the weld shall be machined substantially flush with the surface of the specimen unless the specimen is bent or offset, in which it shall be machined all over. Cast and other irregular specimens shall be machined all over. It is essential that the edges of all specimens be machined to remove material in a condition likely to cause premature failure.

The thickness, t, of a weld specimen shall be as nearly that of the base metal as possible.

(b) *Weld Metal.* A specimen may be prepared from a bar of weld metal prepared as prescribed for tensile tests (Section V, 4-A). The box, Fig. 3, shall however have a width of 1.75 inches and the thickness, t, of the specimen shall be that of the test weld. These specimens shall be machined all over.

(B) Apparatus

In order to load the specimens so that as large a part of the bend as possible shall occur in the weld metal, the special fixture outlined in Fig. 6a and 6b shall be used. It is most conveniently used with any standard universal testing machine but may be operated by any other convenient mechanical means.

The cylindrical surface, D, (Fig. 6a) about which the specimen is bent shall conform to the requirements of the American Society for Testing Materials for bending tests of the base metal*. This piece is attached to the under side of the moving head of the testing machine. Upon the platform shall be fastened two blocks having machined top surfaces and polished corners of radius, R, of 1.00 inch. These blocks shall be separated by a distance, W, equal to D plus 2T plus ⅛ inch. A lubricant of lard oil and graphite or similar compound shall be used on these surfaces.

Two specimens shall be tested. The load shall be applied at the center of the weld,—in one specimen to the open side of the "V" and in the other specimen to the closed side.

The rate of application of the load shall not exceed that at which the beam can be kept balanced at all times or a maximum of 2 inches per minute.

**For ship-plate steel* (58000-68000 *lb. per sq. in. tensile strength*), *it is "The test specimen shall bend cold through* 180 *degrees without cracking on the outside of the bent portion, as follows: For material ¾ in. or under in thickness, around a pin the diameter of which is equal to the thickness of the specimen; for material over ¾ in. to and including* 1-¼ *in. in thickness, around a pin the diameter of which is equal to* 1-½ *times the thickness of the specimen; and for material over* 1-¼ *in. in thickness, around a pin the diameter of which is equal to twice the thickness of the specimen.*

The angle through which the specimen is bent may be measured by any convenient method. The following method is described as a matter of information.

A piece of paper is held firmly against the edge of the specimen when it is in place on the testing fixture and a line drawn on the paper along a corner of the specimen, thus outlining the shape of the specimen so far as bending is concerned. A line is drawn before loading and after failure occurs. The change in the angle in the two lines as determined with a draftsman's protractor is the angle through which the specimen had been bent at failure. See Fig. 14.

(C) Tests Results to be Recorded

(a) The total angle through which the specimen has been bent when the first crack appears upon the convex surface (that is, the sum of the angles through which the two halves were bent). To be measured without removing the load.

Note: An electric light and mirror will assist in observing this surface as indicated in Fig. 6b.

(b) The load on the specimen at which the first crack occurs.

7. *Fatigue Tests, Base Metal, Weld Metal and Weld.*

There is no generally accepted unit or standard of comparison for fatigue tests so that the results given by the several machines which have been developed for such tests are not directly comparable. It is not practicable at the present time to recommend the use of any particular type of machine and consequently test specimens are shown for all of the more common types.

Although in general the results of fatigue tests are of maximum value only when compared with similar results obtained on the same machine, it is assumed that reference tests two days were required to complete the repair. Even so, the saving in both time and money over replacement was a big item, and one of the innumerable instances confirming the im-

Consider the INGOT—
its physical properties

The structure of the Ingot is one of the very important items in the manufacture of Welding Wire.

The defects which appear in the Ingot will be present in the resulting wire almost in direct proportion to the area.

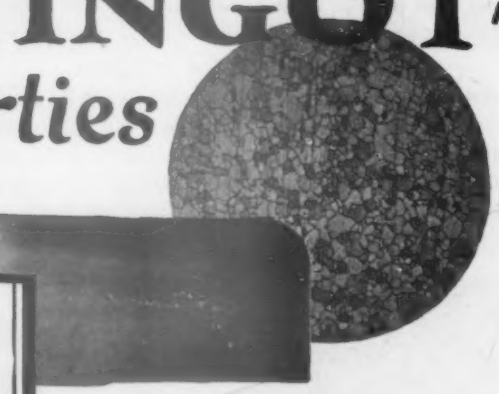
The checked edges shown in the typical steel ingot contain films of oxide which will be evident in wire made from such ingots.

Welding Wire containing oxides and physical defects is detrimental to sound welds.

PAGE-ARMCO Welding Rods and Electrodes made from ARMCO Ingots as shown have therefore the guarantee of uniformity throughout.

PAGE-ARMCO Welding Rods and Electrodes fulfill all the requirements of the American Welding Society Specifications.

Carried in stock by distributors in all industrial centers



Section and Photo Micrograph of ARMCO Ingot Iron Ingot

Section and Photo Micrograph of Typical Mild Steel Ingot

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portance of welding as an indispensable economy factor in modern industry.

will be made on the base metal so that the results of tests on welds and weld metal can also be stated in terms of the results of tests of base metal. It is hoped that this will permit direct comparisons between tests made with different types of machines.

(A) *Machines and Test Specimens*

(a) *General.* For tests of weld metal it will be necessary to form a suitable bar in a box similar to Fig. 3 and having the proper dimensions.

Fatigue tests specimens should in general be machined all over (except the ends) and the surface carefully polished (preferably with the polishing marks parallel to the longest

Fig. 14. Testing Machine.

axis of the specimen). No. 1 Manning emery cloth or paper or its equivalent will produce a satisfactory surface.

Provided the specimens are prepared from a test weld or other material of greater thickness than the specimen, an equal amount shall be removed from both sides so that the specimen shall represent the material at the middle as indicated at a and b, Fig. 7.

(b) *Upton-Lewis Improved Machine.* This machine puts a bending load on the specimen which is reversed during each revolution of the machine.

Specimen shown in Fig. 7. The distance between the jaws of the machine shall be ½ inch. If the specimen is a weld specimen, the jaws shall be equidistant from the center of the weld metal.

(c) *Farmer Machine.* This machine was designed specially for testing weld specimens. It tests the specimen as a simple rotating beam with free supports at the ends and two equal loads on a section at the middle. Specimen shown in Fig. 8. If the specimen is a weld specimen, the weld metal shall be at the center.

(d) *Strohmenger Reverse Torsional Machine...* Comparative results only can be obtained as there is no means of determining the stress. This machine loads the specimen in torsion which is reversed for each revolution of the machine.

Specimen shown in Fig. 9a.

(e) *Strohmenger Bending and Impact Machine.* Comparative results only. The machine strikes the specimen which is held as a cantilever beam, bends it and releases it. This operation is repeated upon the other side of the machine. The weld, if any, is placed just outside the clamp in such a position as to develop the maxmum stress in the specimen.

The specimen is shown in Fig. 9b.

(f) *Moore Machine.* This machine was designed for the Bureau of Standards for testing large size specimens of joints, both welded and riveted. It loads the specimen as a simple beam at the third point and the direction of loading is reversed for each revolution of the machine.

Specimens. Any thickness not exceeding about 1 inch, width 8 inches, length 32 inches. If the specimen is a weld specimen, the weld metal shall be at the middle of the length of the specimen.

(g) *White-Souther Machine.* This machine loads each end of a rotating specimen as a cantilever beam. It is then rotated.

The specimen is shown in Fig. 10.

(B) *Test Results to be Recorded*

(a) Number of cycles of the stress required to cause failure. A cycle is the period of time at the end of which the repetition of the variations of stress is begun.

(b) The stress developed in the specimen (if possible).

RECENT DEVELOPMENTS IN SPOT WELDING

During the last few years the demand for faster production, the development of the automobile, and the natural progress of our industries has greatly enlarged the field of usefulness for the electric resistance welding process, and there has naturally been a tendency to study the machinery used with a view to improving it as far as possible. The undoubted merit of resistance welding in production work has been in itself a stimulus for carrying it nearer to perfection so that all industries may make a wider application of it.

Resistance welding does not leave a great deal to the skill

— FIRST AID TO GOOD WELDING —
To weld, blacksmith heats work in fire, then hammers. This machine welds by heating work electrically, then pressing. First use enough pressure to get proper heat, then turn heat off and apply full pressure.
Spattering metal, or burned work, indicates too much heat or too little pressure. Slow heating and poor welds, indicates the opposite. Adjust heat by regulator. Handle pointing on 8, means most heat; less heat as numbers decrease. Top handle controls pressure. To decrease, turn clockwise.
Paint, scale, or rust at the point of weld, retard, if not altogether prevent, electricity from passing and heating work. The cleaner the stock, the better the results, and the lesser the wear on welding points and dies. If welding points, or dies, heat unduly, make sure that water is circulating through them.
Keep welding points, or dies, clean. Working face for spot welding electrode should be about 5/46" in dia. To reproduce thread in welding points use 31/64" drill and tap with 3/16"—12 threads per in. tap, with tops of threads ground down to 17/32" in dia.
Keep the entire machine clean. Oil moving parts occasionally. From time to time inspect for loose connections.
AMERICAN ELECTRIC FUSION
CORPORATION

Instructions Printed on Panel of Spot Welder.

of the operator. His instructions are few and simple and no previous knowledge of the work is necessary. Consequently, the most important improvements in this field will have to be made in the machinery. The latest machine that has been put on the market is the vertical spot welder made by the American Electric Fusion Corporation. Its design embodies several interesting features which indicate how carefully the matter of improved resistance welding is being studied.

This type of machine is suitable for either light or heavy work. Its moving parts are balanced so that a sense of touch

can perceive proper pressure for good welding, yet the parts are designed to withstand the heavy strain that is likely to be imposed on the machine.

The machine is of box type construction throughout. This construction enables all mechanically moving parts to be completely enclosed. Likewise all high-voltage apparatus is completely encased, making it a "safety machine," that will stand strict inspection.

The treadle design is unique in that it permits the operator to work it in the most convenient manner from any distance away from the machine. Yet the movement of the foot is always the same, giving the same unvarying pressure on the welding points whether the machine is the one with 12-inch or 56-inch depth of throat.

The lower current carrying horn is carried on a heavy box construction support, which in turn is operating on special beam constructed ways. The electrical contact is on each side of the bar. Thus, no matter how the horn itself may spring due to any considerable pressure on its extreme end, the connection to the transformer will not be affected, but on the contrary will wipe itself, similarly to a knife switch, into a better contact.

The movable contacts on the operating arm are mounted on a common shaft, the arrangement being such that the contacts are opened by gravity assisted by a strong spring action. The operating magnet has a permanent air gap which prevents the switch from sticking in the closed position, at the same time a device known as a shading coil is provided to eliminate the hum and clatter. All switches are mounted on black asbestos ebony and are accessible only after a door is removed on which a danger signal is located. Copper contacts are provided for breaking the current and in closing they have a very slight wiping motion then roll against each other and are finally pressed together. All contacts have ample overload capacity and can be renewed by taking out a single screw without disturbing any other part of the switch. The welding points are copper die castings and can be adjusted at any angle, hence they are called "Any Angle" welding points. The draw bolt is made from an alloy that will not rust and its diameter is large enough to permit passages ⅛ inch square, for cooling water.

For the benefit of the operator a set of instructions is furnished on an etched metal panel which is attached to the side of the column.

TORCH CUTS METAL SIDEWALK

Getting more business for the welding shop is usually a question of finding new applications for the torch or the arc.

Cutting a Metal Sidewalk.

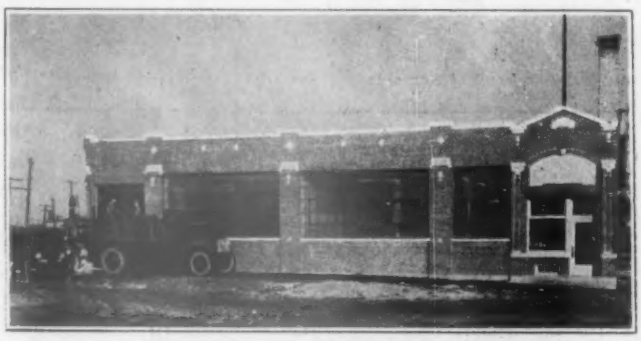
An interesting application of the cutting torch is shown in the accompanying photograph. Here an operator is cutting the sidewalk in front of the building occupied by the Chicago Hardware Foundry Company. The walk is made of a combination of metal and glass, and the rapidity of the cutting torch makes this process of cutting it far superior to any other cutting device.

NEW OXYGEN PLANT IN KENOSHA

The Wisconsin Oxygen & Hydrogen Co. is the name of a new company which began operating what is believed to be one of the most modern electrolytic oxygen and hydrogen plants in this country. The plant is located in Kenosha, Wis., and began operations on January 15th, but already plans for doubling its capacity are being made.

The building is of brick and steel construction and represents the last word in plant design. A side track next to the plant makes it possible to ship easily by railroad or by truck.

This new oxygen plant marks industrial development in



New Plant of the Wisconsin Oxygen & Hydrogen Company.

Kenosha, North Chicago, Waukegan and other North Shore cities. Practically every industrial community of importance contains one or more oxygen plants and the fact that this new plant is running to capacity only a few months after its installation shows that the Kenosha territory is of industrial importance. The men responsible for this new industry in Kenosha are Messrs C. P. Brant, J. R. Brant and W. L. Brant who have been identified with the oxygen business for a number of years in Indianapolis. Mr. W. R. Schoonover a newcomer in the oxygen field is the resident manager of this new Kenosha project.

ALL WELDED STEEL SAND BOAT

The accompanying photograph shows a steel sand boat made at Arkansas City, Kansas, every joint of which was welded. The boat is 22 ft. by 4½ ft. by 4 ft. There are ten trusses through the center of 4 in. by 4 in. angle iron, braced with 4 in. I-beams. All trusses and braces are welded. Its weight is 22 tons. The boat was built on a sand bar, all machinery loaded and placed in position, and then the sand was

This Welded Boat Weighs 22 Tons.

pumped from beneath until it floated. No leaks of any account developed. The sand boat is equipped with a 120-horsepower engine, ten-inch manganese rotary pump, carries 24,000 pounds of concrete for machinery bases, and 25 tons of machinery. Sand is pumped from the boat about 125 yards to the cards. The same company will begin at once the construction of another boat for the same purpose.

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Welding Instruction Is Progressing

THOUGH it is true that the welding industry needs a broader system of instruction for operators, there is ample indication that more progress is being made every year. Many of the state universities and several of the private technological institutes include some form of welding in the curriculum. Welding is an indispensable part of a complete automobile course. It is being taught in a number of Y. M. C. A. trade schools. The increasing importance of the low priced automobile, the tractor and motor-operated farm machinery in agricultural districts has resulted in the addition of "mechanical" or "industrial" departments in the secondary schools and here welding begins to make entry into the common schools. There is no indication that the country is being flooded with poorly trained operators yet it seems certain that these centers of instruction cannot all provide competent instruction in the art. The increased attention that is devoted to welding instruction will serve to make the various processes and their applications better known.

Testing Welds

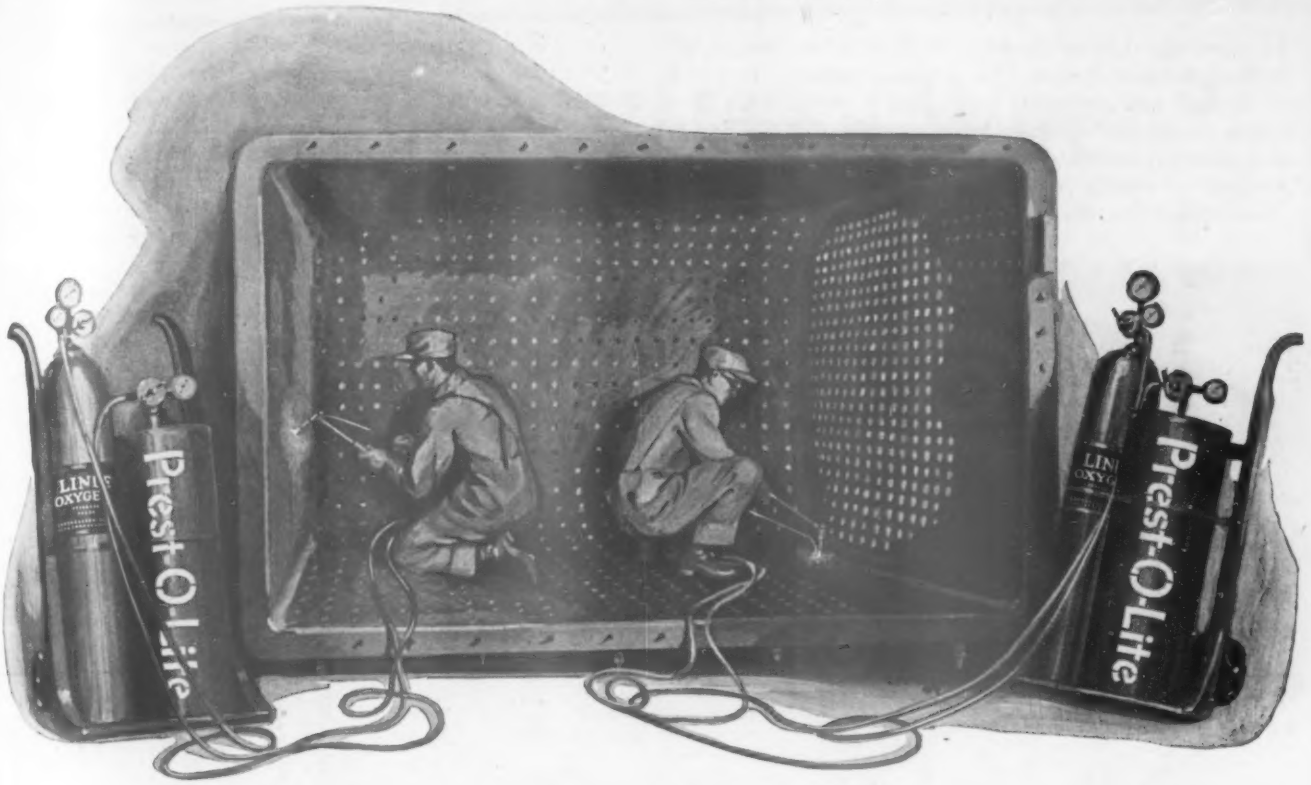
A COMMITTEE of the American Welding Society has recently completed the task of recommending a set of standard tests for welds. The recommendation includes shop tests, commercial tests and research tests. The description of these tests as published in this issue of *The Welding Engineer* are therefore of interest and value to all members of the industry. The simple tests which enable the shop owner or foreman to make a check on the skill of a new operator will not contribute the information concerning the characteristics of the weld which the research engineer demands; and by the same token the welder in the repair shop lacks the facilities and time required for research. The grouping of these standards for tests has been well done, and the details of procedure have been carefully worked out. It remains to establish the real value of these standard tests by putting them into practice. Changes will undoubtedly be found advisable at the end of the year's time that has been suggested for working with these standards, and these changes should be formulated with practical applications of the present standards as a basis.

Economy in Production

A MANUFACTURER who had been worried for several years by labor troubles finally arrived at a partial solution of his difficulties by inventing a machine which eliminates twenty operations from his production method. A necessary adjunct to the device is the acetylene torch, which substitutes a series of tack welds, made in a few seconds, for a longer and far more tedious operation. This is a typical example of the possibility of extending the use of welding. An outfit installed in one department gradually suggests further uses. Invariably a new application results in economy in production. If the work is well done it results in a better product as well.

Up-to-date Welding Service

"SERVICE" is a favorite word with the man who advertises. The welder who advertises to any extent has to emphasize the word, for service is the best thing he has to offer. The outfit that typifies up-to-date welding service is the outfit that can go to the work when it is not expedient to bring the work to the welder. One large truck will carry an arc welding equipment and a gas welding outfit complete with an air compressor and accessory tools. It can cover a large territory and effect big savings in time and labor. The motorized welding outfit is used extensivvely in the United States and the service it can render assures success.



Baptizing a fire box with flame

ONE reason why the oxy-acetylene process is today so widely used in shops and yards for scientific reclamation and manufacture is that

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in readily portable cylinders permits the use of the process both under roof or in road maintenance to the best possible advantage.

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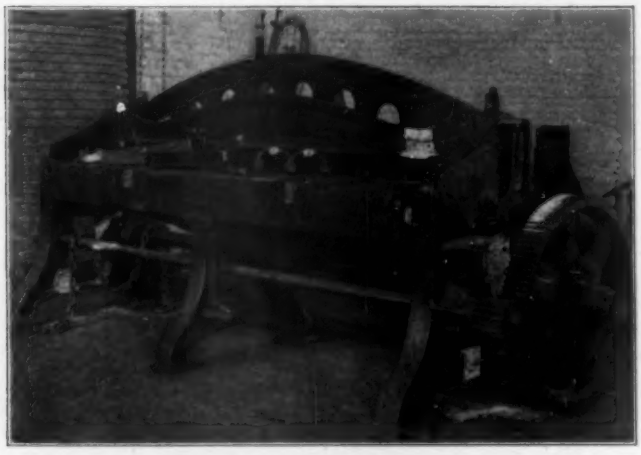
WRECKED SHEAR RECLAIMED BY WELDING

The $3,000 metal shear shown in the illustration was broken in thirteen different places. In common parlance it was a "total wreck," and not many years ago it would have been worthless except for a nominal value as scrap. In this day of modern welding, however, broken machinery of all kinds can be repaired so readily, so cheaply and so satisfactorily that the first thought is always for reclamation.



Welding Saved This $3,000 Shear.

In this instance the big shear was shipped to the Newark welding shop, of the Oxweld Acetylene Company, where it was made over by the welding operators, at a charge to the customer of a very small fraction of its former value. There were no unusual features encountered, and the job is cited only as being typical of what has now become every-day practice in the up-to-date oxy-acetylene welding shop.

ADDED EVIDENCE THAT CAST IRON CUTTING HAS REAL COMMERCIAL VALUE

Instances indicating the value of cast iron cutting as a real economic factor in industry continue to multiply. The following cases are fairly typical of its emergency uses:

The superintendent of a large Indiana manufacturing plant, asked if he ever had occasion to cut cast iron, replied in the negative. In his opinion, it might be an entertaining stunt, but he saw no practical utility for the practice in his plant. Curiously enough, a few days later in remodeling some of the powdered coal furnaces in the power plant, it was found that the cast iron floor plates for the upper deck were several inches oversize and would have to be cut off. The plates had been hoisted and bolted into position at one end before it was discovered that the other ends extended over instead of resting on the center of the supporting "I" beam. The attempt to correct the fault by cutting off the excess lengths with drilling tools proved very slow work. After two and one-half days of continuous drilling, during which time gangs of brick masons and machinists were forced to wait in idleness and only two of the four plates had been cut, the superintendent ordered a cessation of the drilling and asked the aid of welding operators to complete the job.

The oxy-acetylene operators cut the two remaining plates in one hour and 45 minutes. The work was done so accurately that the finished plates were found to line almost perfectly with the center of the beam. The plates were 1¼ inches thick and 60 inches long, the operation consuming 310 cubic feet of oxygen and approximately 100 cubic feet of acetylene. An interesting feature was the fact that the cutting was effected directly over and without injury to the beam and without any difficulty on this account.

JERRY AND JIM

By Weldon

Jerry is strong on Science, but Jimmy goes him one better.

"Ain't that one elluva luck," says Jerry, "here I have been weldin' this doggone thing three times already and it's still acrackin'."

"Well maybe you did and mebby you didn't," Jimmy butted in, kinder sly like.

"Mebby nothin'," hollored Jerry. "You sawed off little shrimp, I have forgot more about weldin' in my time than you ever knowed."

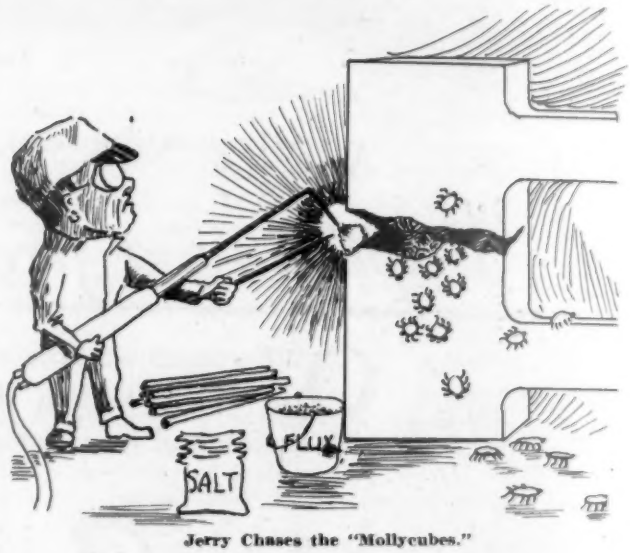
"Mebby so, mebby that's just it," says Jimmy, mild like and all the while smilin' out the corner of his eye.

Jerry was good and sore all thru and got to swearin' somethin' scandalous. The way he bawled out Jimmy was fierce and then he did some tall explainin'.

"I'll tell you what's causin' this," Jerry palavered, "it's the cussed mollycubes what's doin' it."

"Never heard of mollycubes," says Jimmy.

"Well, I reckoned you didn't, you poor fish. You think you knowed somethin' about weldin' and then you don't even know what a mollycube is. Now listen Jim, a mollycube is what you might call a metal-cooty, it just eats up all the carbon. That's what it is doing all right and when you once



Jerry Chases the "Mollycubes."

get them in the weld, then it's good night. What you will get is a lot o' rotten dirt and blowholes. One time when I was weldin' a whale of a cast iron frame, I run into them and believe me, boy, it was some job to clear them out. I had to use up all of a whole sack o' salt with the fluxin'. That's the only thing what kills them. You oughta seen them comin' out, loads an' loads, swimmin' like a scum on a frog pond. That's the whole trouble, boy. Get me?"

Jimmy got awfully disgusted and then he let out strong.

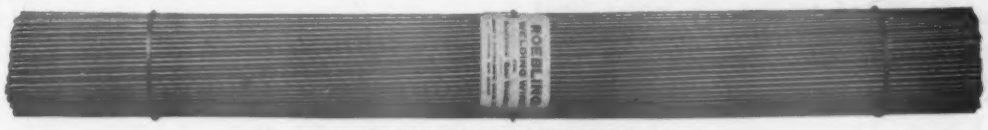
"Where did you get that stuff, Jerry?" he said. "You sure talk like one o' them sales guys what's shootin' off their gab. When they ain't got the stuff they let loose a lot o' gas about mollycubes an' metal-cooties an' carbuncles an' that kind o' junk. You fellows make me sick. When you are weldin' why in blazes don't you do it then? Here I have been watchin' you foolin' with that thing all day. You are too blasted lazy to heat it good an' weldin' it cold don't ever do it. That bunch o' weldin' sticks you got is nothin' but dirty stove iron and you ain't got brains to know that much. You aint even holdin' your weldin' flame right, neither. Half the time it looks like an old paintin' brush, that's my idee, if anybody likes to know."

Jerry was sure stumped the way Jimmy called him and he shut plum tight the rest of that afternoon, what was mighty unusual.

Roebling Welding Wire

ROEBLING ELECTRODES

Roebling Wire Electrodes are supplied in the following standard sizes: ¼-in.; 5/32-in.; 7/32-in.; 3/16-in.; 5/32-in.; 1/8-in.; 3/32-in., having a standard length of 14-in., in bundles 50 lbs. each, and are always available for quick shipment. Sizes other than the above and as large in diameter as ½-in.; having any length required, either straightened or in coils can be furnished on order.



ROEBLING WELDING STICKS

Roebling Wire Gas Welding Sticks are copper coated to distinguish them easily from Roebling Electrodes. They are supplied in standard sizes: 5/32-in.; 7/32-in.; ¼-in.; 5/16-in.; 3/8-in.; 7/16-in.; 5/16-in.; 7/32-in.; and in standard lengths of 36 in. in bundles weighing 50 lbs. each, well protected by weatherproof paper or burlap. Sizes other than the above either straightened or in coils can be furnished on order.

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Hold on! What were you doing just then? Storing away that interesting bit of welding experience, or a photograph, perhaps? Don't do it? Give it to us. We want to show it to 5,000 other readers of The Welding Engineer (you're the fifty-one hundredth). If there are objectionable features to it, just leave it to the Editor (he studied surgery), cutting off and adding to is his hobby.

Another thing, when you work out a successful solution to a welding problem write us about it. Grammar and composition don't count—it's ideas we want. If a sketch would illustrate your job in good shape, just make a rough pencil sketch; our draughtsman will do the rest.

If the welding industry is to grow, you welders must pass along your experiences. We pay for them.

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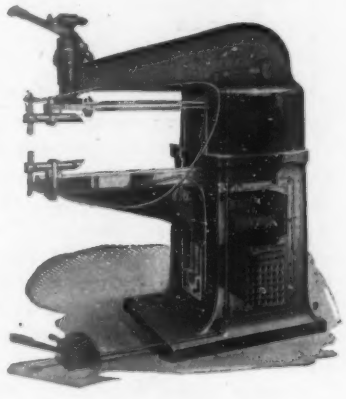

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SPOT WELDERS
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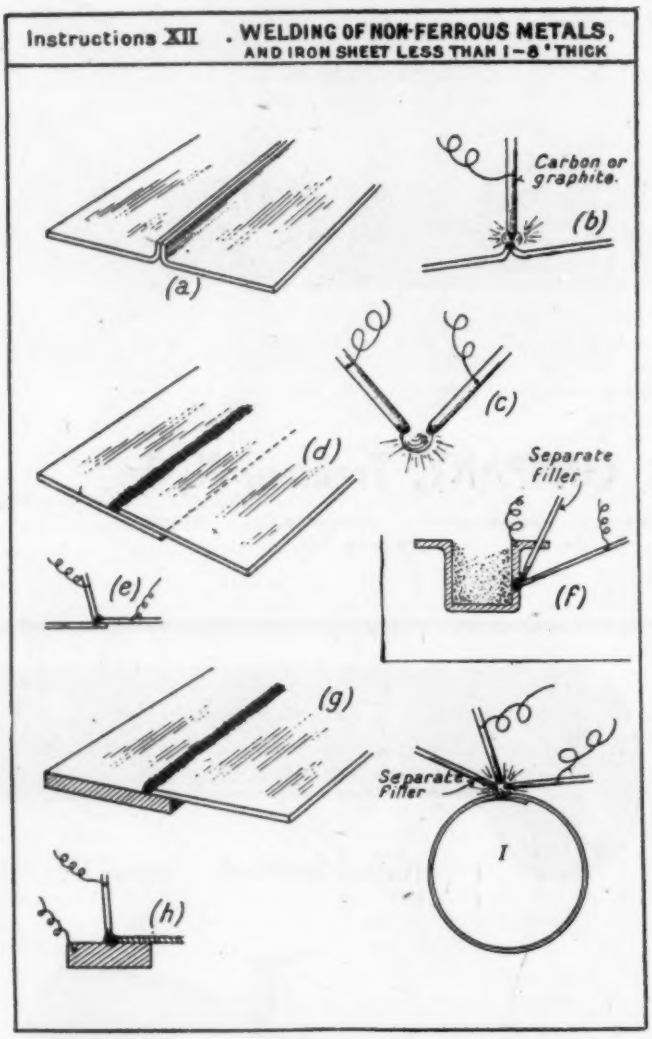
WELDING OF NON-FERROUS METALS

(i. e. Metals Other Than Iron and Thin Iron Shapes.)

THE welding of non-ferrous metals and the welding of thin iron plate are very similar, i. e., the problem here is that, there is no viscous point, the metal is either solid or fluid, and when fluid, unless exactly horizontally level and backed up by some heavier colder piece, will melt and run away.

If the pieces to be welded are backed up by the heavier metal piece, or if they are in a trough shape with the "V" of the trough at the bottom, welding with the electric arc is very



easy by ordinary methods, but various arrangements must be provided in order to keep the fluid parts from running out of place. The simplest and most effective arrangement is as shown in Figure A, the adjustment of two plates, i. e., copper, aluminum, bronze, brass or thin sheet iron being so arranged that there are two vertical abutting edges. The arc, whether from a graphite electrode or from a metal adding electrode similar to the plates to be welded, is then run rather rapidly along this edge, melting the two vertical edges together into a single bead, as shown at B.

Copper tanks, thin sheet water packets and many other uses allow electric welding to be applied to these jobs. Welding entirely automatic has been done in this manner, simply passing the edges at an even rate under the arc.

Figure D shows the method of two overlapping plates. The arc being held mostly from the upper plate, as shown at E, allowing the underplate to serve as the recipient of the molten bead. In welding with the graphite arc there is the choice of the single graphite rod with the work as one electrode, as shown at B, or of the double graphite, or carbon arc, as shown at C, with the work under any part of the electrode.

These two methods offer distinct solutions for various jobs in that the single graphite method is similar to metallic electrode, and on pulling away the heat in the arc is increased due to the voltage having increased across the arc. This, on thin work or non-ferrous method generally, results in a hole or a burned spot. With the method shown at C, the action is similar to that of the gas torch, i. e., the flame can be pulled away from the work and the amount of heat supplied to the work lessened, the heat being constant and the amount supplied to the work being in direct proportion to the distance of the flame from the work. This allows of thinner and more delicate work being accomplished than the other method, and allows of two plates being floated together more delicately than with the single electrode method.

As shown in Figures F and I, a separate filler electrode can be used as with a gas flame by either the single graphite or the double graphite arc. Figure F shows the method of welding aluminum crank case with the inside of the crank case moulded around the spot to be welded with plastic asbestos which serves to keep the original shape of the crank case while the aluminum is fluid, i. e., aluminum has no well-defined viscous point as has steel. Aluminum, copper or bronze in general require a mould of plaster of paris or asbestos to be made to keep the metal from flowing away after being melted by the arc, unless work is so thick that it serves as its own backing. Figures G and F show method of applying a small section to a larger one. Here the metal electrode can be used successfully, the arc being drawn mostly from the large section, carefully watching the edge of the lighter section to see that it does no more than flow into the puddle made in the larger section.

Lead burning can be easily and quickly accomplished in the following manner: In any machine where 6 to 10 volts are available and 80 to 100 amperes by the use of a graphite or carbon rod about ¼ inch in diameter lead can be either burned loose or welded together in the following manner:

Place the carbon in the electrode holder with various lengths protruding according to the current desired; in other words, if too quickly heated a longer length of carbon protruding will cut this current to point desired. The carbon is pressed against the spot to be welded. It will glow white hot at the end shortly. The lead will then melt without oxidizing if there is not too great current allowed and in this molten state can be worked about so as to burn loose or weld together as desired. Seams can be welded in this manner or any of the known uses of lead burning.

The spotting of cylinder bores with the nickel electrode and the spotting of pins to the head, such as the retaining pins of ballbearings require an arc that is self extinguishable, that is, not a sustaining arc which can only be put out by pulling away. The only known means of providing this characteristic is by A. C. or low voltage D. C. by a flash non-sustainable, which results in the spotting desired, and the arc does not have to be pulled out which would form an ugly crater because maximum heat is applied at the finish. Another use for this type of arc is tacking spots where it is highly undesirable to have a crater where the work is generally thin and craters would be fatal.

**Instruction No. 12 from the handbook of the Electric Arc Cutting & Welding Co., 152 Jelliff Ave., Newark, N. J. Copies of the complete instruction book may be had from this company at $1.25 each.*

The Pittsburgh Reinforced Brazing & Machine Co., Pittsburgh, have developed a high-pressure oxygen compressor with a capacity of 45 cubic feet of free oxygen per minute, compressing it at 2,000 pounds pressure per square inch. Another of their products is cylinder valves for high-pressure gas cylinders.

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DISCUSSION ON:—"EFFECT OF HEAT TREATMENT ON NITRIDE IN METAL ARC WELDS

S. W. Miller*

In the discussion of the strength of electric arc welds made with bare mild steel electrodes, it should not be forgotten that as yet there is no proof that the so-called needles are nitride of iron or that the eutectoid, which has the appearance of pearlite, is really partly composed of iron nitride, because as yet the chemical composition of these items has not been determined. In spite of this, I believe that the needles and eutectoid are really caused by the presence of nitrogen. The facts are that the structure of arc welds resembles iron that has been subjected to the action of ammonia at high temperature.

Comstock has shown that certain etching reagents will show a difference between iron nitride and iron carbide, which strongly resemble each other in appearance when the usual etching methods are used. It is also impossible that the white constituent called iron nitride can be all iron carbide, because then the carbon content of electric welds would be very high, and it is well known that it is not over 0.05 or 0.06 per cent with usual electrodes. Again, the iron nitride is easily scratched with a needle, while iron carbide is not.

It is not at all impossible, however, that carbon has something to do with the structure because Wheeler has found that the treatment in ammonia carbonizes the outside of the piece, so that its carbon content becomes as much as 0.64 per cent in 48 hours at 750 deg. C. (Table published in "Mining and Metallurgy," April, 1920, "Nitrogen in Steel and the Erosion of Guns," by H. E. Wheeler.)

The author of this paper states that the carbon comes from impurities in ammonia, such as carbon monoxide, carbon dioxide, acetylene or methane. I have, however, found no iron carbide in the form of small islands of cementite in electric welds, although they always contain some carbon, say up to 0.05 per cent. It therefore appears probable to me that the carbon is part of the eutectoid which is visible in electric welds.

I do altogether agree with Mr. Wheeler in his contention that iron nitride is not visible in steel containing nitrogen, because the lines and eutectoid visible cannot be produced alone in the amount existing, so that the lines and the eutectoid must be due at least in part to the nitrogen, even if the carbon does have something to do with their formation.

With regard to the effect of these lines and the material of which they are composed on the metal, it should be remembered that the dark lines usually shown by etching are not the needles, or more properly speaking, the plates themselves. The plates are exceedingly thin in electric welds, probably usually not over one-one hundred thousandths of an inch thick, and the dark lines seen are simply due to the iron being dissolved away from around the plates by the action of the etching fluid. This can be readily shown by etching in steps, when it will be found that light etching brings the lines out, while further etchings make them wider and wider.

I have shown quite clearly, and it has been confirmed by Mr. H. S. Rawdon of the Bureau of Standards, that the slip bands caused by the distortion of an arc weld, do not bear any relation to the plates and that therefore they are not a source of weakness in the weld.

I have never seen an arc weld ruptured at a nitride of iron plate or crystal, or at any spots of eutectoid, so that I cannot believe that nitride of iron has anything to do with the brittleness of arc welds. There is no question that the iron nitride goes into solid solution when quenched at the proper temperature, but it would seem that under these conditions there should be no nitride of iron at the grain boundaries and therefore there is no evidence given that nitride of iron is responsible for any increased brittleness of specimens so treated.

It may be of interest to note that Dr. Henry Fay of the Massachusetts Institute of Technology, in speaking of the effect of nitrogen on case-hardened pieces, states "that the evidence all points to its being beneficial, adding to strength and hardness up to certain limits." (Nitrogen and Case Hardening, "Chemical & Metallurgical Engineer," February 16, 1921.)

It has been my experience that needles are not always present, but that there is always present either the needles or a white constitutent resembling in appearance cementite and that the two do not exist close together except in rare instances.

Specimen No. 7, Table 1, does not have the nitrogen content given, but the tested strength is somewhat greater than specimens No. 1 and No. 2, which were tested without being heat treated. These two latter specimens give 46,500 lb. and 52,000 lb. tested strength, while specimen No. 7 shows 54,000 lb. there being more difference between No. 1 and No. 2 than between No. 2 and No. 7, so that it is doubtful if the treatment caused the increase. I am also inclined to doubt that such a short treatment as 15 minutes would increase the elongation 156 per cent.

In studying metal arc welds it must be remembered that they are exceedingly irregular in quality and that before any laws can be deduced from tests on them, the number of tests must be sufficient to eliminate these irregularities.

An examination of the tables given in the paper show this very clearly. For instance, at 1,800 deg., Table II, there are two test pieces. The variation in the elongation as given is 130 per cent. At 900 deg. the variation between the minimum

* *Proprietor, Rochester Welding Works.*

and maximum elongations of the three test pieces is 409 per cent of the minimum. At 800 deg. the maximum tested strength 78,000 lb., is 167 per cent of the minimum 47,750 lb.

In table 3-A, the data is far more meager and an endeavor is made to deduce laws on the basis of one test piece for each temperature, which is certainly insufficient. For instance, it is inconceivable that a mere change in the quenching temperature from 1,800 deg. to 1,700 deg. all other conditions being the same, would increase the tested strength from 10,540 lb. to 69,500 lb., an increase of 559 per cent.

Again, the tensile strength at 1,000 deg. quenching temperature is given as 9,486 lbs. while at 900 deg. and 1,100 deg., it is about 26,250 lbs. (1,100 deg. — 31,500 lbs., 900 deg. — 21,000 lbs.) It would seem impossible that this great change in tensile strength should occur simply because of the slight variation in quenching temperature. In table 3-B, which gives the results of specimens quenched after heating for five minutes instead of fifteen minutes as in table 3-A, at 1,300 deg. the tensile strength is given as 37,000 lb. while in 3-A it is given as 18,500 lbs. It does not seem possible that an increase of only ten minutes would decrease the tensile strength 100 per cent at this low temperature.

Again, the tested strength in table 3-B, at 700 deg. is given as 82,750 lb., while at 800 deg. it is 67,500 lb., and at 600 deg., 65,500 lb. There would seem to be too much variation at such low temperature in such a narrow range to warrant any conclusion which would be at all accurate.

Further, if it is supposed that the figures are accurate, there are two variables, one of which is the time, and the other, the difference in method of cleaning the layers of the deposit, and the effect which can be assigned to each one cannot be determined.

A comparison of table No. 2, with table No. 3 shows that it is necessary to have a large number of test pieces before any conclusions can be drawn, because there is a wide variation in table No. 2, between the test pieces at the same temperature, and it would seem fair to assume that there would be an equally wide variation between the results under quenching conditions, where it is much more difficult to control the temperature at which the pieces are quenched. Further, if we assume that the figures in table No. 3 are correct, and that the curve as drawn gives the law, there must be a critical point at every 100 deg.

One very important matter which has been entirely overlooked by the authors is where the rupture occurs in these specimens. It has been my experience that in electric arc welds this path of rupture is always intergranular, the first evidence of it being at visible defects in the welds which are really grain boundaries. This is true no matter what treatment the piece received, and is the result of the examination of several hundred welds.

There is only one heat treatment with which I am familiar which will in any way increase the ductility of a metal arc weld, and that is heating it in a reducing atmosphere. Of course the higher the temperature at which this is done, the less time required, but a period of two hours at 1,200 deg. F. with air cooling of the specimen will notably increase the ductility. I have no quantitative results because of the difficulty of getting arc welds that are uniform. Specimens heated in an ordinary furnace are made more brittle because of the oxidizing atmosphere.

Andrew produced brittleness in ordinary steel by heating in a slightly oxidizing atmosphere, and removed it by the treatment referred to above. My experience is that all brittle steel has an intergranular rupture, which means that the grain boundaries must be weaker than the rest of the material. These grain boundaries are apparently more readily attacked by oxygen than the crystal line matter of the grains, so that there is probably formed at the boundaries a thin film of oxide which, being non-metallic, has no ductility. The reducing atmosphere changes the oxide to metal and increases the ductility of the specimen. I admit that the explanation I have given is theoretical and I doubt that absolute proof can ever be presented of its accuracy. Certainly a very large number of tests would be needed before it could be accepted, but it is in accord with all the facts known at the present time. It means that oxygen and not nitrogen is the element in welds that causes their brittleness. My belief is that this is true in all steel.

There is one other point which should be mentioned, which is that the Owens test, in my opinion, is not quantitative, that is, that tested strength cannot be fairly determined by it. It is a splendid test for checking up welders, but when it is attempted to use it to determine the real physical qualities of material, I am of the opinion that variables, such as friction between the pin and the ring, are such that no accurate results can be obtained.

On the other hand, if the results are accurate, it simply shows the futility of attempting to deduce laws from such irregular material as that which exists in arc welds, unless a very large number of pieces is tested.

H. S. Rawdon *

A study of the properties of steel after fusion by the electric arc is of fundamentad importance in the study of arc welding. As a part of such a general study of arc-fused steel which was carried out by the Bureau of Standards, considerable attention was paid to the thermal characteristics of such material. The results obtained may be of interest here in supplementing and explaining some of those of Mr. Owens.

In Fig. 18 are given heating and cooling curves of a specimen taken from low-carbon steel electrodes used for welding and

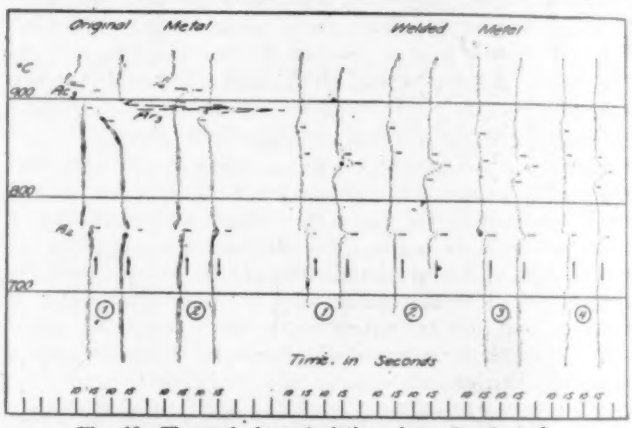

Fig. 18—Thermal characteristics of arc-fused steel.
The direction of arrow indicates whether the curve is a heating or a cooling curve. The numerals indicate the number of "runs" taken on the same specimen.

also of the same material after arc-fusion. Observations upon the "arc-fused" specimens were taken during the cooling, down to 150 deg. C (300 deg. F), but since no indication of any transformation below these shown in Fig. 18 was obtained, the curves were not reproduced in full in order to avoid excessive reduction in size during reproduction. A "pearlite point" might be expected in the unfused specimen. The carbon content was so low, however, that any transformation corresponding to the formation of pearlite would be very inconspicuous.

The composition of the material before and after fusion was as follows:

	Before fusion per cent	After fusion per cent
Carbon	0.02	0.03
Silicon	0.16	0.006
Sulphur	0.04	0.04
Nitrogen	0.004	0.13

It is evident from the above that the carbon-content was not affected by the fusion and that the silicon was practically all removed. The most striking change was the increase of nitrogen in the material. It is this element without doubt, that was the cause of the changes in the thermal curves shown in Fig. 18.

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The principal effect consisted in the lowering and partial suppression of the A_3, or gamma-iron change, the A_2 or magnetic change being unaffected throughout all the heatings. It is quite evident from Fig. 18 that a nitrogen content in iron of 0.13 per cent causes non-ritical or transformation points of itself, at least such as would be revealed by thermal analysis.

Fig. 19 shows that a large number of "nitride-plates" were present in the arc-fused metal after the thermal analysis "runs" and it is evident from a comparison of Fig. 19 a and b, that the form and size of the "nitride-plates" changed very considerably during the heating incidental to the thermal analysis. No pronounced energy change however accompanied their formation.

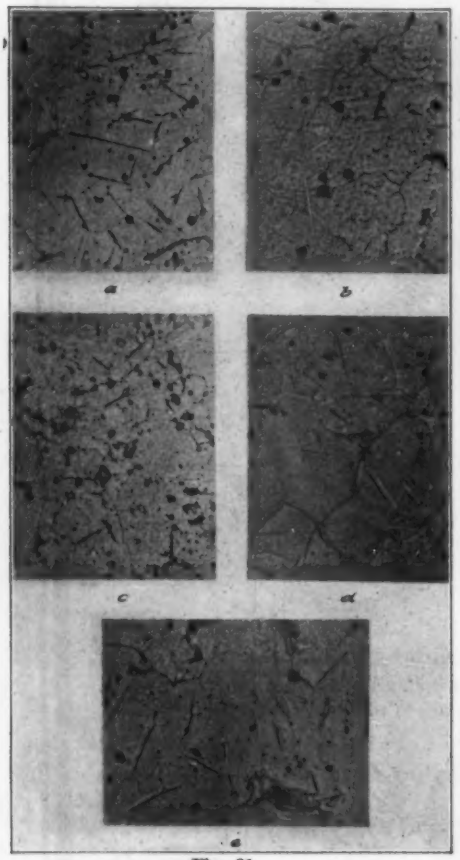

Fig. 21.

Fig. 20.

Fig. 19—Microstructure of the arc-fused metal used in thermal analysis. × 500.
The specimen was heated four times as shown in Fig. 1. The total length of time above the temperature of the Ac_3 transformation was 6 hours. A, initial structure as fused; B, structure after heating. Etching reagent, 2 per cent alcoholic solution of nitric acid.

Fig. 20—Microstructure of Arc-Fused Steel After Quenching in Water from 1000° C. × 500.
The plates characteristic of the material before heating have disappeared and a martensitic pattern has been produced. Etching reagent, 5 per cent alcoholic solution of picric acid.

Fig. 21—Microstructure of arc-fused steel, showing the effect of heat treatment.
The specimen was quenched in water from approximately 1000° and reheated as shown below. A, arc-fused metal as deposited; B, same as A after quenching and subsequently reheating to 650° C; no "plates" have been formed by this treatment; C, a quenched specimen was reheated to 700° C; a few plates have appeared; D, a quenched specimen was reheated to 800° C; E, a quenched specimen was reheated to 925° C. Etching reagent, 2 per cent alcoholic solution of nitric acid.

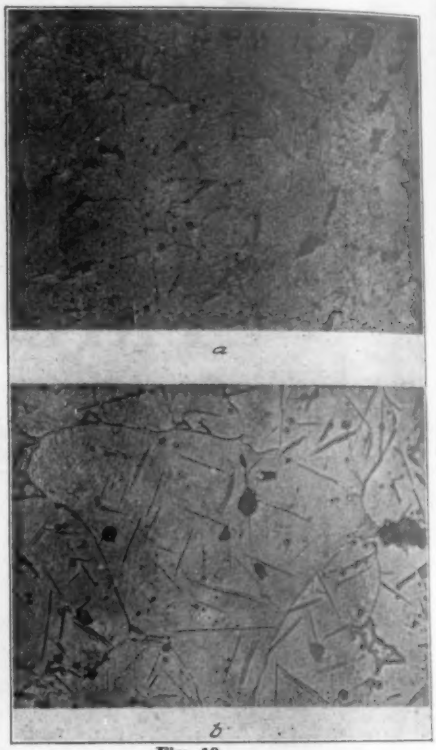

Fig. 19.

The temperature at which the lines reappear in arc-fused metal which has been quenched was determined by heating specimens quenched in water from 1,000 deg. C (1,830 deg. F), to various temperatures as shown in Fig. 21 and then examining the material microscopically for evidence of the reappearance of the lines. Fig. 20 shows the structure of the quenched specimen, no "nitride lines" were found but the material showed a circular or martensitic pattern throughout the grains. Fig. 21 is self explanatory; no lines were found in quenched metal after reheating to 650 deg. C (1,200 deg. F), but by heating to a slightly higher temperature, 700 deg. C (1,200 deg. F), a few of the lines formed. By heating to successively higher temperatures, they became more and more pronounced. Some of the "pearlite like" islands were found in the specimen reheated to 925 deg. C (1,700 deg. F).

This general behavior of the quenched arc-fused iron upon reheating is confirmed by the observations of Ruder[3] upon the behavior of nitrogenized electrolytic iron upon reheating after vigorous quenching.

It would appear from the above results that the explanation offered for the change observed in the mechanical properties of specimens of arc fused metal reheated after quenching should be modified somewhat since the pronounced changes occur at a temperature considerably below that at which the "nitride lines" become visible under the microscope. Perhaps the explanation should be along somewhat the same lines as that used for the tempering of hardened steels. It is well-known that in "drawing" a martensitic steel very pronounced changes in properties, mechanical as well as chemical and magnetic, occur at temperatures far below those at which the structure shows visible change.

James W. Owens

The basic idea underlying this research, when undertaken, was to relate the metallographic structures observed in a metal arc deposit with corresponding physical characteristics.

Believing that the metallographic structure and physical characteristics were affected by the rate of cooling I felt that if this was varied within a wide range it would be possible to obtain some conception of the influence of this factor.

With this in view, test specimens were deposited as follows:

(a) On pipe sections which were flattened and thru which water at a temperature of approximately 50 deg. F was flowing.

(b) On ½ inch ship plates at atmospheric temperature.

(c) On ½ inch ship plates which were kept hot by gas torch during the period of depositing the metal.

In examining these specimens under the microscope differences in structures were observed and physical tests showed corresponding differences. Deposits on the water pipe gave high tensile strength but low elongation, viz., 59,260 pounds per sq. in. and 2½ per cent, respectively, (average of 6 specimens); deposit on ship plate at atmospheric temperature gave an average tensile strength and average elongation, viz., 50,610 pounds per sq. in. and 6 per cent, respectively, (average of 6 specimens); deposit kept hot during welding gave lowest tensile strength and low elongation, viz., 29,000 pounds per sq. in. and 2½ per cent respectively, (1 specimen). A standard tensile test specimen was used for all of the foregoing tests.

It was now apparent that a more detailed analysis was necessary and as the number of test specimens required was unusually numerous (over 88 being tested) the ring shaped specimen was used instead of the standard rod or bar specimen. The specimen being small and easily prepared reduced time and expense to a minimum. The small size of the specimen permits a deposit of reasonable size from which can be cut all the specimens desired for any test, thus eliminating a number of indeterm-

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inate factors such as varying chemical composition of the electrode, fatigue of the operator, etc., which would have been introduced by the use of the standard specimen referred to.

Mr. Miller questions the accuracy of the test data, due to the method of testing employed. It is unfortunate that Mr. Miller is not acquainted with the test as it exists today, but only knows of it in its early stages of development, when a tapered conical plug was inserted in the cylindrical hole of the ring and no allowance made for variable friction. The test is now, not only suitable for "checking up welders" as Mr. Miller agrees, but was specifically developed with the latest refinements so as to make this research possible, furthermore problems of testing peculiar to welding demand solution even if that solution is attempted by methods not regarded as standard practice.

An outline of the test is as follows:

The ring shaped specimen is placed on a hardened steel die which rests on the base of a standard tensile testing machine and expanded to the point of fracture by a hexagon shaped piug which bears against a sector-like hexagon wedge inserted in the hole of the ring. The surfaces of both plug and wedge are carefully hardened and ground to secure a constant coefficient of friction. The load required to break the ring is not on the testing machine and the true breaking strength calculated, proper allowances being for friction as noted.

The per cent elongation is obtained by measuring the circumferential stretch of the ring by a suitably designed gage. Calibration curves for both friction and per cent elongation are used, the accuracy of which have been verified by checking against standard tensile specimens. All parts of the apparatus in proper alignment being constructed as a unit for use with any standard tensile testing machine.

In a letter received from Mr. Eicholtz of the Westinghouse Electric and Manufacturing Co., relative to the paper, he says:—"I am particularly interested in noting that you have obtained ultimate tensile strengths as high as 83,000 lbs. per sq. in."

Using a standard tensile test specimen I have obtained a tensile strength of 72,000 lbs. per sq. in. for a mild steel electrode deposit cleaned with brush only and in view of the fact that specimens in the test which showed a strength as high as 82,750 lbs. per sq. in. were specially prepared by removing the slag with a pneumatic roughing tool and were then heat treated, it does not seem unreasonable that this strength should be obtained.

In interpreting these curves allowance has to be made for the non-uniformity of a metal arc deposit when cleaned with a brush only as in Table Nos. I, II and IIIA, but marked changes in direction of curves as plotted for quenched specimens would certainly subordinate the importance of this factor in interpreting them. This is also true of the short annealing curves and if smooth curves were drawn through the points plotted they would indicate that short annealing does not apparently alter the tensile strength but by its means the highest elongation possible can be secured by heating above 1000 deg. F and slowly cooling as outlined in the paper.

Not much significancec is placed by the authors on the long and very annealing curves shown nor the 1800 deg. point of the quenching curve plotted from Table IIIC, this data being only included as a possible aid or check on future research.

Test Specimens:—Tables 1, 2 and 3A were cut from deposits, each layer of which was cleaned with the brush only and as results were not always consistent it was decided that in checking test 3-A by test 3-B, that deposit must be free from slag, therefore, each layer in this case was cleaned with the pneumatic roughing tool (using the lowest possible air pressure) thus securing remarkably perfect specimens. By referring to curves it will be noticed that those plotted from Table 3-B are consistently higher in both tensile strength and ductility than those plotted from table 3-A, which leads us to believe that these curves mutually check each other.

It is not intended that the conclusions drawn by the authors from this research are absolute or final and it is hoped that other investigators will parallel this research and see whether conclusions arrived at can be verified. In any case the authors themselves, as is stated in the paper, purpose to again carefully check all their data. This is a fundamental research for, in order to secure consistent annealing results, we must develop a standard technique, which at least we have attempted to do. This technique will enable us not only to anneal the weld and heat affected area of the base metal, but will permit us to develop that required for the annealing of built up shafts, etc.

J. A. Watts.

The condition of brittleness is generally conceded to iron that has been oxidized. This brittleness may perhaps be removed by annealing in a reducing atmosphere, namely, by reducing the iron oxide to metallic iron, but what becomes of the oxygen set free by this reduction? If hydrogen has been used, the formation of water is inevitable, which ultimately means blow holes or pockets in the metal so treated.

If oxygen is the main cause of brittleness in metal arc deposits, then oxygen alone, when associated with iron must impart greater brittleness to iron when quenched above 1,000 deg. F. All data seems to lead to the conclusion that oxidized iron is brittle no mattter what treatment it has received.

The foregoing statement seems to indicate that some element other than oxygen must be the cause of the brittleness found at and above 1,000 deg. F. Nitrogen seems to meet this requirement as this element passes into solid solution near 1,000 deg. F. This simply means that the transformation of the nitrogen from the forms visible under the microscope to the related solid solution robs the weld desposit of what litle elongation it formerly possessed. Whether the fracture of iron containing nitrogen in solid solution is inter or trans crystaline has not as yet been investigated by the authors.

It seems probable as Mr. Wheeler has stated that not all of the nitrogen in a weld is visible, some being retained dissolved in the iron. The majority of the nitrogen so dissolved, I have found, can be thrown out of solution by annealing, followed by very slow cooling. Or, in other words, metal arc welds, due to their varying rates of cooling may contain some of the nitrogen in solid solution and some in the visible forms (needles and plates), thus imparting varying degrees of brittleness to the deposited metal.

No transformation point as revealed by thermal analysis is apparent, as stated by Mr. Rawdon, but the effects of a transformation is readily detected by the microscope. It seems probable that nitrogen in combination with iron acts similarily to the Cooper tin compound in certain bronzes, for slow cooling of deposited metal from a certain temperature (950 to 1,000 deg. F) allows all of the dissolved nitrogen or nitride of iron to be thrown out of solid solution, ultimately assuming the needle-like form. Mr. Rawdon suggests that, "Perhaps the explanation should be along the same lines as that used for the tempering of hardened steels." This thought has already been considered by the authors, for specimens have been drawn at varying temperatures, subsequent to quenching and very interesting physical and metallographic changes noted.

Mr. Miller states that when the plates of nitrogen are visible no needles are found in the immediate vicinity. This is true as the plates under different conditions of cooling coalesce into the needle-like forms. Weld metal often contains plates and needles but as stated by Mr. Miller, one form predominates over the other. The amount of nitrogen present and the carbon content may influence this difference of form when regarded from the standpoint of temperature.

Finally the total lack of ductility of metal arc deposits when quenched at or near 1,000 deg. F is to my mind beyond dispute for at least twenty-five specimens were quenched around this temperature and tested, all showing the same results. Specimens were secured from deposits made with different material and at different times.

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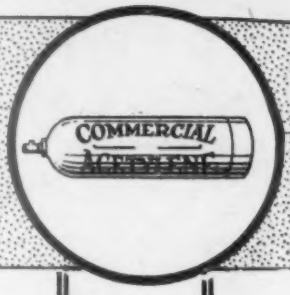

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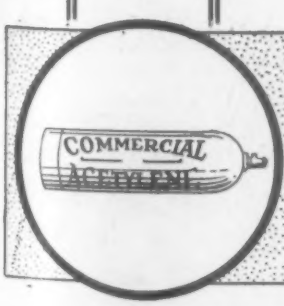

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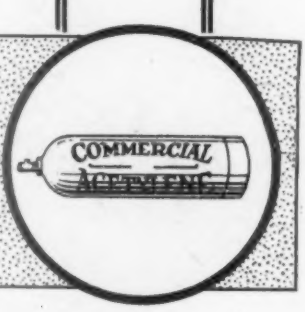


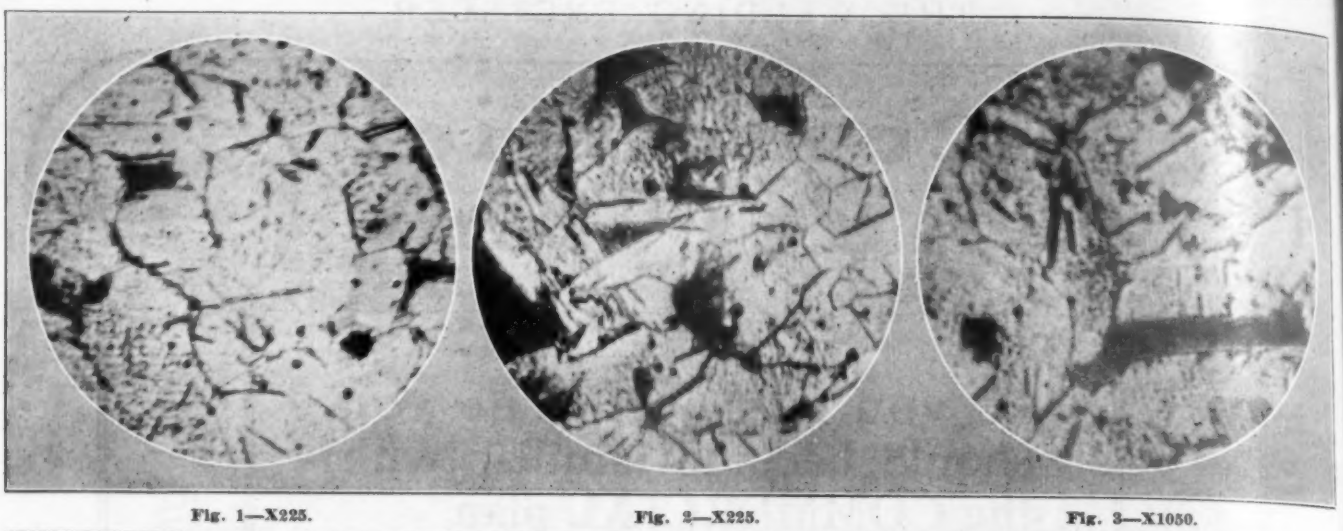


Fig. 1—X225. Fig. 2—X225. Fig. 3—X1050.

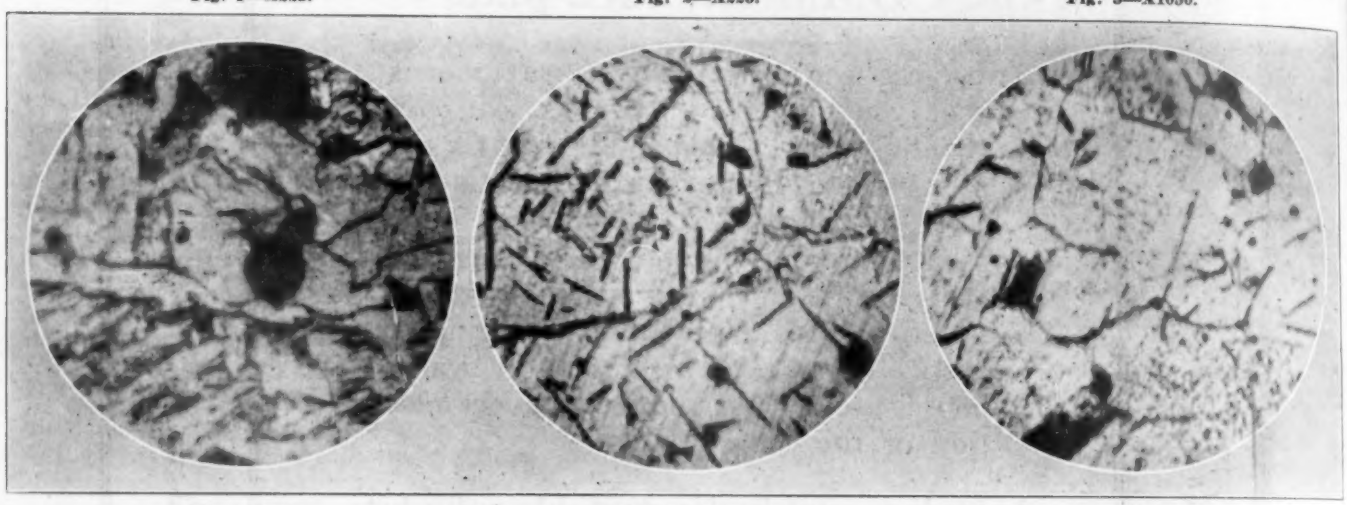


Fig. 4—X900. Fig. 5—X900. Fig. 6—X225.

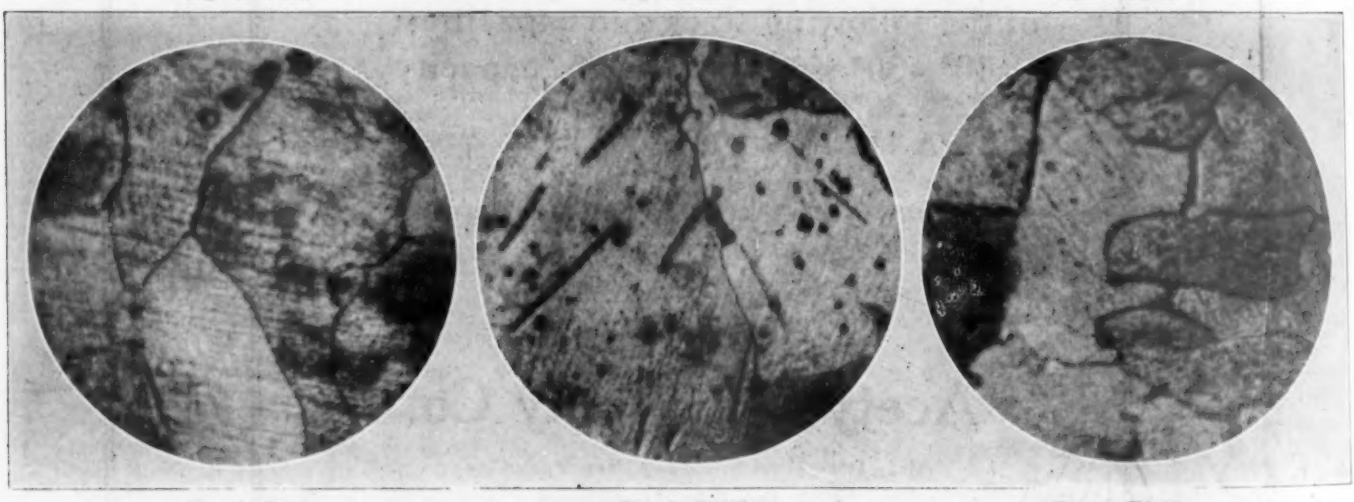


Fig. 7—X900. Fig. 8—X1050. Fig. 9—X1050.

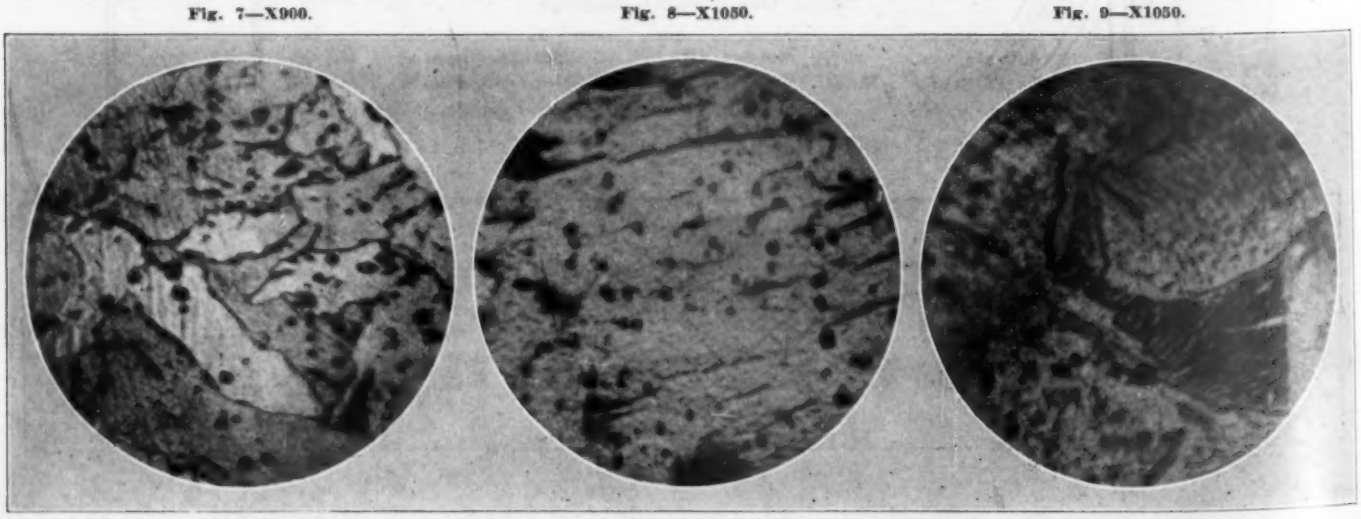


Fig. 10—X1050. Fig. 11—X1050. Fig. 12—X1200.

J. H. Ramage.

The first part of Mr. Miller's discussion has to do with the identity (or lack of identity) of the needles. No attempt was made by the authors to prove that the needles are iron nitride, but it was simply stated that "it is now almost unanimously agreed that the needles are an indication of the presence of nitrogen in the metal, probably in the form of iron nitride." The needles were called nitride throughout the paper simply as a means of identification, however, aside from this point, no evidence was presented to prove them other than nitride. The long annealing treatments would have removed them had they been strain lines or slip bands; they certainly do not resemble twining lines, for a comparison of the amount of carbon present (.06%), the area of the pearlitic-like constituent and number of lines, considered also with the structural changes produced by the heat treatment eliminates even the consideration of these areas as being martensite, carbide or pure pearlite. To stress the point, the lines have been found in pure iron nitrogenized by the decomposition of ammonia gas, as Mr. Miller has stated, which would eliminate any undiscovered effect due to the excess of oxide commonly found in welds.

Mr. Miller's contention that the needles (nitrogen present in this state) do not render the iron brittle is supported by the authors in the following statement: "The needles appear to have no effect upon the ductility or strength of the ferrite, acting merely as a mechanical inclusion. Mr. S. W. Miller mentions this in his paper on 'The Path of Rupture in Steel Fusion Welds.'" The point which we desire to emphasize is that the constituents of these needles when in solid solution in the ferrite do render the iron extremely brittle. This brittleness is also unlike the loss of ductility accompanying hardening due to solution of iron carbide (as suggested by Mr. Rawdon), in that, the solid solution is no harder and may even be softer than the partially annealed or even long annealed form. The hardness figures in Table 1 of the paper would indicate simply a difference in hardness due to grain size of the iron.

Remarks concerning condition of an ordinary weld as to the number of needles, predominance of pearlitic-like areas or variations in brittleness can have no quantitative bearing in this discussion since the amount of nitrogen present and the rate of cooling can differ sufficiently to account for quite wide different parts of the same weld under normal working conditions. Very rapid quenching is necessary to retain all of the needle-like constituent in solid solution. On the other hand annealing for periods considerably longer than an ordinary weld is likely to get and at temperatures slightly below 900 deg. F. is necessary to remove any considerably amount of the needle-like constituents from solution, and in the majority of welds made under ordinary working conditions will be in some stage of the transition from one form to the other.

We do not dispute the embrittling effect of oxide, nor the fact that this oxide brittleness is evidenced at grain boundaries, which would be the logical place to look for rejected impurities, but apparently the embrittling effect of the dissolved nitride is such as to reduce the ductility of the iron still further.

To sum up the presence of this dissolved nitrogen compound in the iron or steel renders it extremely brittle making it hot short when above 900 deg. F. (solution point), and cold short when this dissolved condition is retained either wholly or partially by various degrees of quenching.

Mr. H. S. Rawdon's discussion brings out several very interesting points.

The micro-photographs upon which we based our conclusions as to the temperature of the nitride solution point were taken on quenched samples. These quenching experiments were conducted in two different ways.

In the first method all the specimens were placed in the furnace and heated until the temperature of the highest quenching point had been attained. The first specimen was removed and quenched, then the furnace temperatuure was lowered to the next quenching temperature, held for a time and the second specimen removed and quenched, etc. By this method it was proved that the nitride remained in solution until a temperature below 900 deg. F. had been reached.

The second method was as follows: The temperature of the furnace was raised to the highest quenching temperature desired, the first specimen inserted and heated a specified time (five or fifteen minutes), then removed and quenched. The furnace temperature was then lowered 100 deg. F., another specimen was given the standard duration of heating and quenched, etc. The results of these quenching experiments proved that the needles went completely into solid solution in some temperature range below 950 deg. F.

In all the tests conducted the change from the brittle state (no elongation) to the first indication of ductility takes place in the samples quenched immediately below 900 deg. F. Microphotograph, Fig. 7, shows the solid solution structure in a specimen quenched at 950 deg. F., and Figs. 9, 9A and 9B show the first appearance of needles in specimens quenched at 850 deg. F. and 775 deg. F.

Our results would indicate a lag in the temperature at which the needles come out of solution, of perhaps 50 deg. F. or so, behind that temperature at which they dissolved.

I think the time element is the main factor in the apparent differences in Mr. Rawdon's and the author's micro-photographic results. Mr. Rawdon's photographs were taken on annealed in the paper, namely, "the transition is not rapid, requiring quite a long period of time at or near this range (800 to 1,000 samples, and on this point we can only emphasize the fact made deg. F.)."

On the opposite page are reproduced Figures 1 to 12 from the paper, "Effect of Heat Treatment on Nitride in Metal Arc Welds." They illustrate conditions as follows:

1. Normal Amount of Oxygen and Nitrogen.—2. Showing Nitride Euctectic.—3. Showing Extra Large Nitride Needle. (2 and 3 Show Large Amount of Oxygen and Nitrogen Produced by Long Arc.)—4. Columnar Grain Structure Produced by Chilling.—5. After Annealing. Showing Needles and Oxide Spots as in Fig. 6, but Pearlitic-Like Areas Have Disappeared.—6. As Deposited.—7. After Quenching. Showing Structure Similar to Pure Metal. Nitrides Have Disappeared but Oxide Spots Still Present.—8. Specimen in Fig. 7 Re-heated to 2000° F. and Cooled in Furnace. Needles Reappear but Fewer in Number.—9. Quenched at 950° F. Showing Nitride Dissolved in Ferrite Causing Critical Point, Also Curly Grain Structure and Darkening Some Grains to a Brownish Shade.—10. Quenched at 850° F. Needles Begin to Form.—11. Pearlitic and Needle-like Form when Quenched at 775° F.—12. Pearlitic-like Form at Higher Magnification.

PROGRAM OF ANNUAL MEETING

Following is the program of the annual meeting of the American Welding Society, held April 27, 28, 29 and 30, 1921, at the Engineering Societies Building, New York:

Wednesday, April 27, 1921

10:00 A. M. Gas Welding Committee, S. W. Miller, chairman.

10:00 A. M. Resistance Welding Committee, Hermann Lemp, chairman.

2:00 P. M. Welding Wire Specification Committee, C. A. McCune, chairman.

2:00 P. M. Welding Conference Committee, A. S. Kinsey, chairman.

Tuesday, April 28, 1921

10:00 A. M. Board of Directors, American Welding Society.

10:00 A. M. Committee on Specifications for Steel to be Welded, W. J. Beck, chairman.

2:00 P. M. Business Session of American Welding Society.

Program

1. President's Report on Year's Activities.
2. Adoption of Proposed Revised By-Laws.
3. Reports from (a) Finance Committee.
   (b) Membership Committee.
   (c) Meetings and Papers Committee.
4. Reports from American Bureau of Welding and its Research Committees.
5. Report of Tellers Committee on Election of Officers.
6. Introduction of new president.

Thursday, April 28, 1921

8:00 P. M. Technical Session of American Welding Society.

Program

1. "Applications of the Automatic Welding Machine," P. O. Noble, to be accompanied with lantern slides.
2. "Production Welding With the Gas Flame," R. A. Malm.
3. "Results of Recent Thermit Welding Research," J. H. Deppeler, to be accompanied with lantern slides. This paper will deal with the standardization of thermit welding practice, the cost and method of elimination of defects in thermit welds, blow holes, shrinkage, cavities, etc.

Friday, April 29, 1921

10:00 A. M. Board of Directors, American Welding Society (new).

10:00 A. M. Electric Arc Welding Committee, H. M. Hobart, chairman.

2:00 P. M. American Bureau of Welding.

Program

1. Progress report.
2. Election of officers.
3. Discussion of organization and policies.
4. Plans for future activities.

Saturday, April 30, 1921

10:00 A. M. Committee on Welding of Storage Tanks, J. C. Lincoln, chairman.

10:00 A. M. Committee on Training of Operators, William Spraragen, chairman.

S. W. Miller, Rochester Welding Works, was elected president and C. A. McCune, Page Steel & Wire Co., vice-president. The eight new directors elected to hold office for three years are: A. S. Kinsey, Stevens Institute of Technology; E. M. T. Ryder, Third Avenue Railway Co., New York; E. Wanamaker, Chicago, Rock Island & Pacific R. R.; J. C. Lincoln, Lincoln Electric Co.; W. T. Bonner, New York Shipbuilding Co.; H. R. Swartley, Davis Bournonville Co.; D. B. Rushmore, General Electric Co., and H. L. Nicholson, Westinghouse Air Brake Co.

ACTIVITIES OF CHICAGO SECTION

At the regular monthly meeting of the American Welding Society, Chicago Section, April 29, R. G. Mason, foreman of welders, Santa Fe shops, read a paper on "The Reclamation of Freight Car Castings," and R. E. Kinkead, engineer, A. F. Mitchell & Son, Chicago, gave a talk on "The History of Electric Arc Welding Apparatus."

The next monthly meeting will be held Friday, May 27, at 7:30 P. M. in the rooms of the Western Society of Engineers, 1735 Monadnock Building. The program will consist of a paper on the "Welding of Pressure Vessels," by C. A. Hollup, and a motion picture, by the Page Steel & Wire Co., showing the development of Page Armco welding rods and electrodes from the ore to the finished product.

A. S. M. E. WILL DISCUSS WELDING AND CUTTING TORCHES

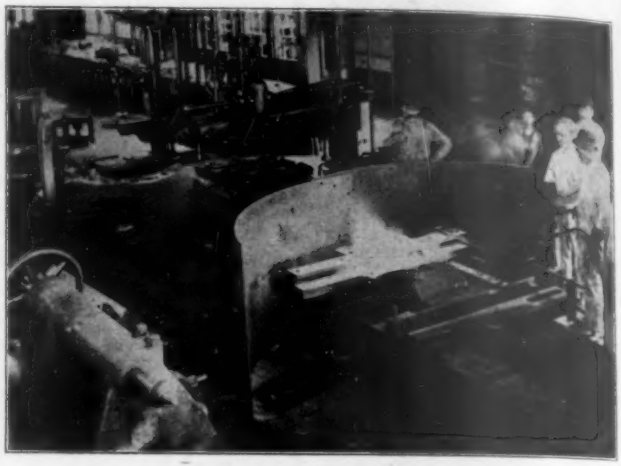
The American Society of Mechanical Engineers, 29 W. 39th Street, New York City, have published a pamphlet entitled "An Investigation of Oxy-Acetylene Welding and Cutting Blowpipes."

This investigation was conducted by the Bureau of Standards, Washington, D. C., and a report was written by R. S. Johnson, of the Bureau of Standards. This report will be read at the Spring meeting of the American Society of Mechanical Engineers, Wednesday morning, May 25th at the Congress Hotel in Chicago.

Members of the welding trade who are interested are invited to attend.

WELDING IN CUBA

That the oxy-acetylene flame has carried its message of modern practice in machinery repair to the industrial plants of the Antilles is evidenced by the extensive scale of American-made welding and cutting outfits in the islands of the Caribbean. The accompanying photograph shows an interesting repair in progress on the carriage of a 48-inch lathe at an



A Cuban Welding Shop.

industrial plant at Felton, Cuba. The big machine has been partially dismantled, the carriage remaining in place, where it is in process of preheating preparatory to welding with the oxy-acetylene blowpipe. The steel sheeting shown in the picture was set up merely as a heat shield. The job was completed in short order and was found to be in perfect alignment and satisfactory in every way.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., REQUIRED BY THE ACT OF CONGRESS OF AUGUST 24, 1912,

Of The Welding Engineer, published monthly at Chicago, Ill., for April 1, 1921.

State of Illinois, County of Cook—ss.

Before me, a Notary Public in and for the State and county aforesaid, personally appeared L. B. Mackenzie, who, having been duly sworn according to law, deposes and says that he is the publisher of The Welding Engineer, and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management, etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 443, Postal Laws and Regulations, printed on the reverse of this form, to wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are:

Name of— Post office address—
Publisher—L. B. Mackenzie, Chicago, Ill.
Editor—L. B. Mackenzie, Chicago, Ill.
Managing Editor—L. B. Mackenzie, Chicago, Ill.
Business Manager—L. B. Mackenzie, Chicago, Ill.

2. That the owners are: (Give names and addresses of individual owners, or, if a corporation, give its name and the names and addresses of stockholders owning or holding 1 per cent or more of the total amount of stock.)

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L. B. Mackenzie, 7131 Chandon Ave., Chicago, Ill.
M. J. Hungerford, 6107 Dorchester Ave., Chicago, Ill.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: None.

4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

5. That the average number of copies of each issue of this publication sold or distributed, through the mails or otherwise, to paid subscribers during the six months preceding the date shown above is —. (This information is required from daily publications only.)

L. B. Mackenzie.

Sworn to and subscribed before me this 29th day of March, 1921.
(Seal.) Stella I. Lindquist.
(My commission expires Nov. 7, 1923.)

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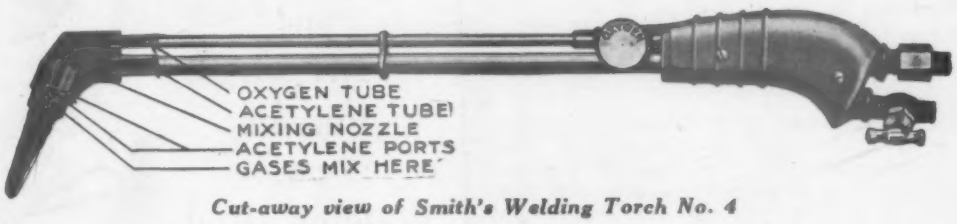
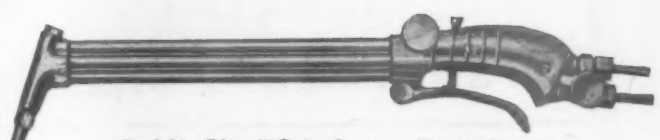
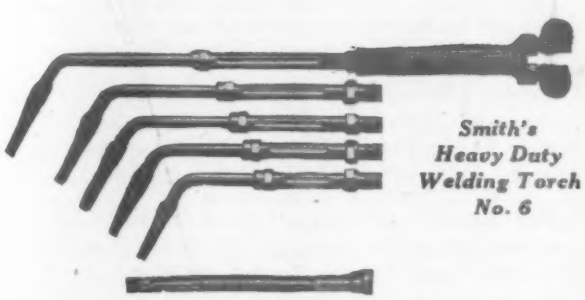


Cut-away view of Smith's Welding Torch No. 4



Smith's Pistol Grip Cutting Torch No. 9



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For Sale—1200-300 lb. generator; 29 No. 2 tips; 2 No. 3 tops; 28 No. 4 tips; 36 torches; 40 single gauges; 38 double gauges; 1 box brass plugs. Prices reasonable. Albany Welding & Boiler Shop, 40 Madison Ave., Albany, N. Y.

Position Wanted—By welder with nine years' experience; all metals; all forms of welding; 29 years old; single; American born; prefers territory outside the United States. Address 72, care The Welding Engineer.

Position Wanted—Welder with 4 years' experience in acetylene and electric arc welding. G. T. Lowry, 2455 Caithness Avenue, Denver, Colo.

For Sale—Low-pressure Osweld acteylene generator; capacity 100 pounds nut carbide, 100 cubic feet gas per hour; in excellent condition; four years old; price 540 f. o. b. our factory. Address Riverside Boiler Works, Inc., 491 Main Street, Cambridge, Mass.

Position Wanted—By welder; experienced in arc and acetylene welding, repair work, tank work, steel barrel and boiler work; married; Chicago or vicinity preferred. Address 73, care The Welding Engineer.

Position Wanted—By experienced welder and mechanic; six years' welding experience. Address 74, care The Welding Engineer.

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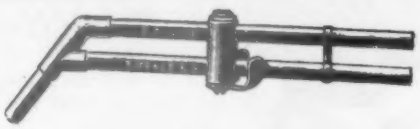

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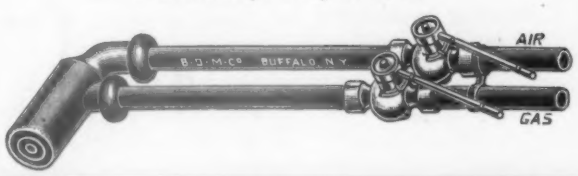

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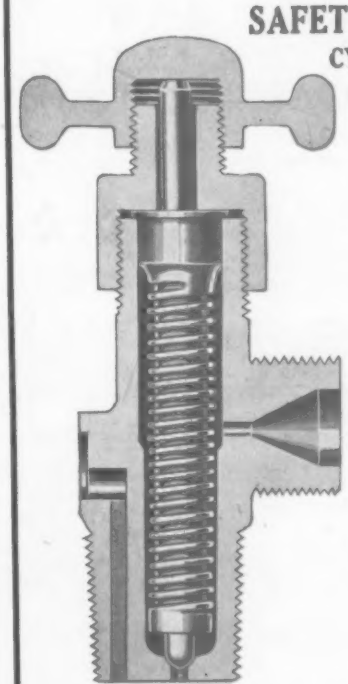

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CURRENT WELDING LITERATURE

NOTES ON SOLDERING AND SOLDERING FLUXES, by E. Andrews.—Preparing work for Soldering. Composition and Use of various solders. Corrosive and non-corrosive fluxes. How to make and use them.—American Machinist, May 12, 1921.

FURTHER USES FOR THE TORCH, by David Baxter.—Use of torch for re-babbitting and punching holes.—Acetylene Journal, May.

INDUSTRIAL APPLICATIONS OF HYDROGEN, by Harry L. Barnitz.—The many and widely varying uses to which this gas is being put.—Scientific American, April, 1921.

BULLETIN NO. 1.—Bulletin of American Electric Fusion Corporation. Describes line of electric resistance spot welding machines.

AN INVESTIGATION OF OXY-ACETYLENE WELDING AND CUTTING BLOWPIPES, by R. S. Johnston.—Results and conclusions from tests made by U. S. Bureau of Standards for the War Department.—Mechanical Engineering, May.

SYSTEMS OF ELECTRIC ARC WELDING.—Descriptions and wiring diagrams of English welding sets.—Acetylene and Welding Journal, London, April.

USES FOR WELDING AND CUTTING.—A list of a thousand and one uses for the oxy-acetylene torch.—Autogenous Welding, April.

CUTTING METALS WITH THE OXY-ACETYLENE TORCH, by David Baxter.—A review of the principles of machine cutting and free-hand cutting.—American Blacksmith, April.

THE TAYLOR ELECTRIC WELDER.—1921 catalog of the Taylor Welder Co., Warren, Ohio. Spot welding machines.

ARMCO IN PICTURE AND FACT.—250 page book published by American Rolling Mill Co., Middletown, Ohio. Illustrates production process of Armco Ingot Iron products. 80 pages of reference and computing tables.

The Chicago office of the Commercial Acetylene Supply Co. has moved to 542 South Dearborn Street.

Charles R. Pollard has resigned from the Trade Research Division of the Goodyear Tire & Rubber Co., Akron, Ohio, to resume the office of the secretary to the Alexander Milburn Co., Baltimore, Md. Mr. Pollard was connected with the Milburn company for ten years prior to joining the Goodyear company in 1919, and will take charge of the territorial development for the Milburn company's products.

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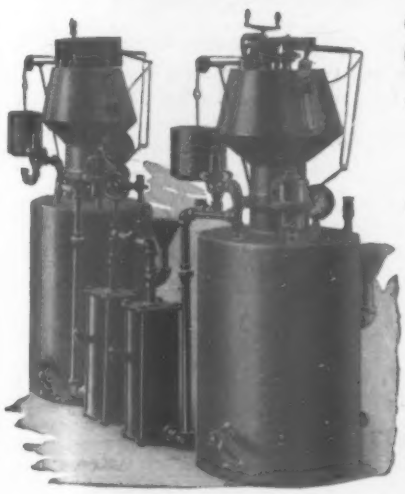

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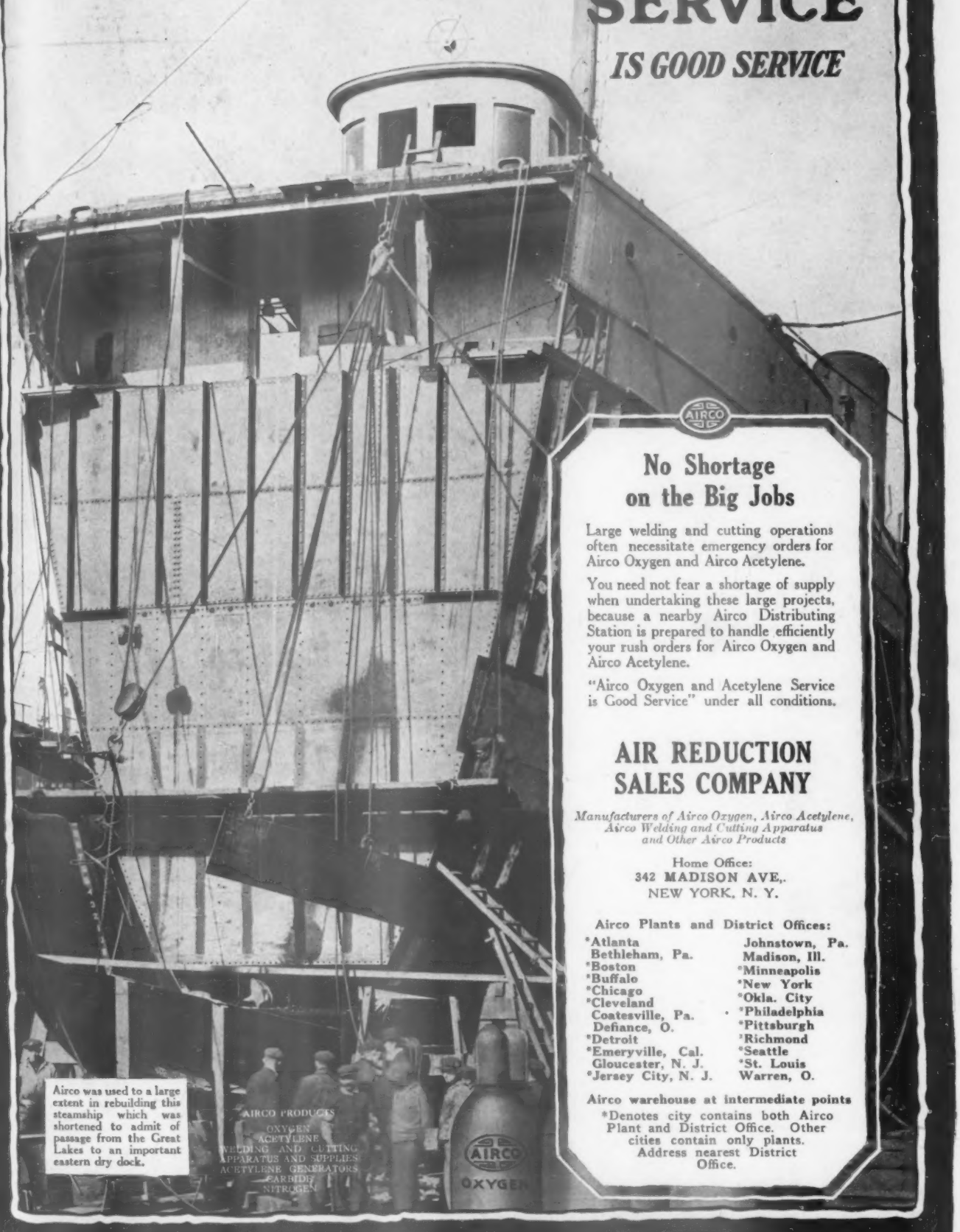

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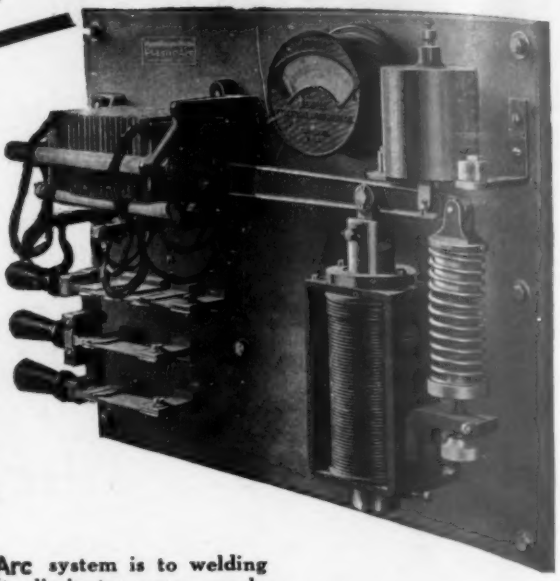

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